U. S. DEPARTMENT OF AGRICULTURE

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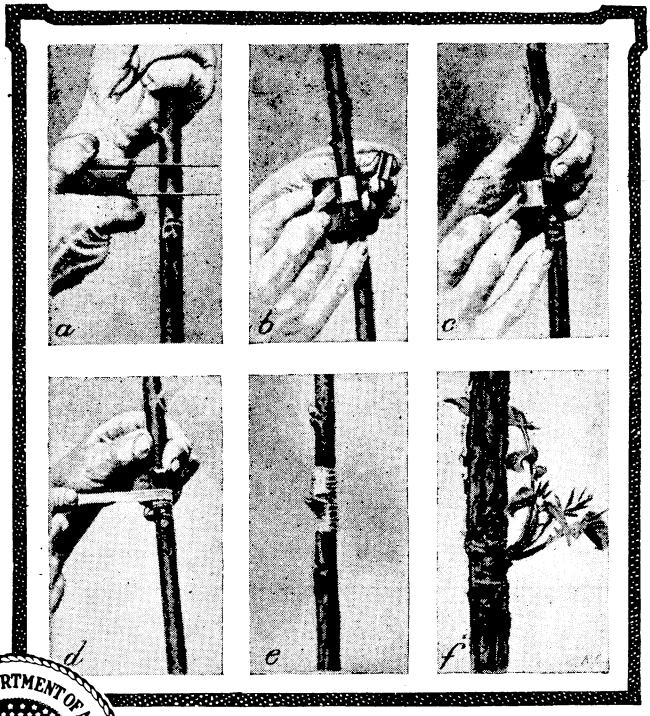
NUT-TREE PROPAGATION



A WORKING KNOWLEDGE of how to reproduce varieties is of great practical importance to all nut growers and orchardists. They should know how to distinguish between seedlings and budded or grafted trees. Those having considerable interests will sooner or later have to top-work inferior trees and introduce new varieties.

The purpose of this bulletin is to provide growers with a working knowledge of how asexual propagation is effected. It is not to encourage the general practice of growing their own trees, as the production of desirable planting stock is expensive, and without experience it is generally unsatisfactory. Under normal conditions it is cheaper in the end to buy such stock from professional nurserymen.

The successive steps in the process known as patch budding, illustrated on the title-page, are described in the text on pages 12–15.

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NUT-TREE PROPAGATION

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INTRODUCTION[1]

THE PRODUCTION OF NURSERY TREES is a highly specialized profession, and under average conditions it is better for planters to purchase planting stock from nurserymen than to grow their own trees. Occasionally catalogue prices may seem high, but the final cost is invariably less than when the average individual undertakes to raise his own planting stock. For the inexperienced propagator, therefore, it is ultimately more satisfactory to purchase trees from a reputable nursery.

The production of high-grade nursery trees suitable for orchard planting involves a continued process requiring knowledge and skill at each of a long series of steps. The selection and care of the seed before planting, the location of the seed bed and the preparation of the soil, the choice of season, the manner and depth of planting, the determination of the distance between the seeds in the row and of space between the rows, the care and cultivation of the young seedlings, the combating of diseases and other troubles, the proper selection of time and technic of budding or grafting, the training of the young trees while in the nursery, and finally the digging and preparation for shipping or transplanting are all steps requiring special knowledge without which costly errors are practically inevitable.

[1] The writer wishes to make grateful mention of the valuable services of many individuals who have helped in the assembling and preparation of the material in this bulletin. It would be impossible to list the names of all those who have been consulted or who have been of direct or indirect help. A few outstanding names, however, are those of Robert T. Morris, New York, N. Y.; J. F. Jones, Lancaster, Pa.; W. C. Deming, Hartford, Conn., and E. R. Lake, close associate to the writer, each of whom read the manuscript while it was in preparation, making valuable suggestions. The following have been freely consulted: O. J. Wenzel, Albany, Ga.; the late Herbert C. White, Putney, Ga.; J. S. Wight, Cairo, Ga.; H. K. Miller, Monticello, Fla.; the late S. H. James, Mound, La., C. L. Edwards, Dallas, Tex.; F. T. Ramsey, Austin, Tex.; the late C. E. Ringer, Ardmore, Okla.; A. M. Gray, Milwaukie, Oreg.; A. A. Quarnberg, Vancouver, Wash.; J. C. Cooper, McMinnville, Oreg.; Homer A. Kruse, Sherwood, Oreg.; Charles Trunk, Dundee, Oreg.; Ferd Groner, Hillsboro, Oreg.; I. Van der Bom, Orenco, Oreg.; C. L. McNary, United States Senator, Salem, Oreg.; Knight Pearcy, Salem, Oreg.; George A. Dorris, Springfield, Oreg.; Thomas P. Littlepage, Washington, D. C.; and Paul White, Bowie, Md.

A high percentage of the trees produced even by experienced nurserymen is often rendered unfit for sale except at reduced prices through failure to observe some of these steps.

METHODS

Nut-producing species of trees are like those of other fruits in that their varieties do not come true to seed. As a rule, nut trees are more difficult to propagate than are fruit trees. Definite varieties may be multiplied only by some method of asexual propagation. The principal methods usually employed are either some form of layering or of budding or grafting.

LAYERING

MOUND LAYERING

Among the more common kinds of nut trees, only the shrub hazels (including filberts) are capable of being multiplied by mound layering. This system often consists merely in removing the suckers which spring from the base of the parent plant, together with sufficient roots to enable them to grow when transplanted. With many varieties these suckers rarely develop at any point except at or near the immediate base of the tree, although with some they occur on the main roots, and occasionally roots torn loose by harrows will send up sprouts to form new plants.

The extent to which suckers appear varies greatly with the variety. With some the tendency may easily be overcome as the tree grows older by carefully paring away the young sprouts close to the mother plant with a sharp knife as promptly as they appear; with others the habit continues indefinitely, and much greater persistence will be required to overcome it.

To stimulate the formation of roots from such a clump of suckers, it is customary to mound up the common base with sandy soil to a depth of several inches or even a foot. When this is done, roots usually develop so rapidly that a year later, if the suckers are shaved off at the old ground level with a sharp spade, numerous roots will be found. At the end of one season's growth the plants should be taken up, set in nursery rows, and cultivated for a full season, in order that they may develop good root systems suitable for transplanting.

One advantage of propagating filberts by mound layering is that of simplicity. Practically all commercial varieties of filbert are inclined to produce suckers, and by the use of this system no great amount of labor is necessarily involved. Multiplication of planting stock is therefore little more than a process of taking up the plants already formed and cultivating them for another year.

SUCKER LAYERING

Propagation through any system of layering is practicable only in sandy or silty soil. Perhaps the most successful and simple method of propagation by sucker layering is one that has been highly developed by A. M. Gray, of Milwaukie, Oreg., illustrated in Figure 1.

The successive steps to be practiced in order to carry out this method successfully are as follows:

(1) If the suckers are numerous, dig a basin about 3 inches deep around the base of the tree, as shown in the figure; if but few are present, a trench extending directly away from the base may be dug for each sucker.

(2) Cut back the tips of the suckers to such length that only 5 to 7 buds will remain. Experience shows that this is about the maximum number likely to develop into vigorous plants from a single layer unless they are allowed to remain undisturbed for an extra year or more.

(3) Pare away the bark on the outer side of the sucker from top to bottom, using a thin-bladed sharp knife.

(4) Bend the sucker over to the ground and securely peg it, face down, as shown in the figure. To facilitate bending, the sucker should be cut about half off 2 or 3 inches above the ground on the side toward the tree.

In Oregon this work is performed at any convenient time from January until early spring, depending upon weather and soil condi-

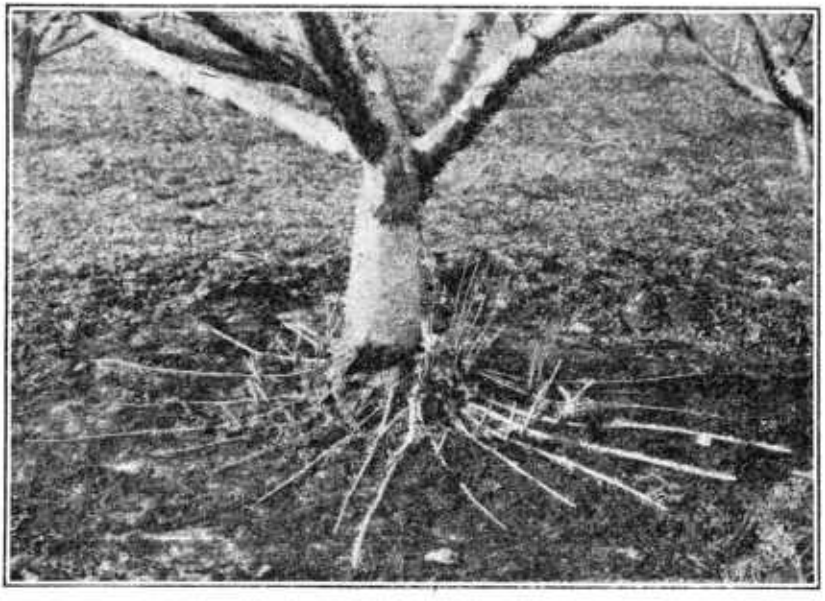

FIG. 1.—Filbert suckers layered in early spring by the Gray method

tions. When the growth from the buds has reached a height of several inches, sandy or silty soil is carefully worked with the hands about the base of the upright shoots to a depth of 2 or 3 inches. More soil is added later in the season while the ground is being hoed and as greater growth makes this possible.

With conditions favorable to growth, by September the new plants should be 2 feet or more in height, as shown in Figure 2. They should be dug in December, when the root systems should be fairly well developed. (Fig. 3.) The layers should be so cut that each upright growth with its due proportion of roots will become an independent plant when transferred to the nursery row to remain under cultivation for another year. At the time of transplanting, the roots are carefully brought together in as direct a downward line as possible and lined out 8 inches apart in trenches 8 to 12 inches deep and

4 to 6 feet apart. A year later the trees should be of suitable size and condition for transplanting.

TIP LAYERING

A common method of filbert propagation is that illustrated in Figure 4 and here called tip layering. It differs from sucker layering in being applicable to the main leader of a young plant as well as to suckers of older plants. By this method a short section of the sucker near the upper end is covered with soil, the very end being allowed to protrude vertically beyond the covering. By a modified form of this method, the terminal branch of any young plant or sucker is bent to the ground at such a curve that two or three buds remain in an upright position along the stem, between the base of the plant and the high point in the curve. These buds will then

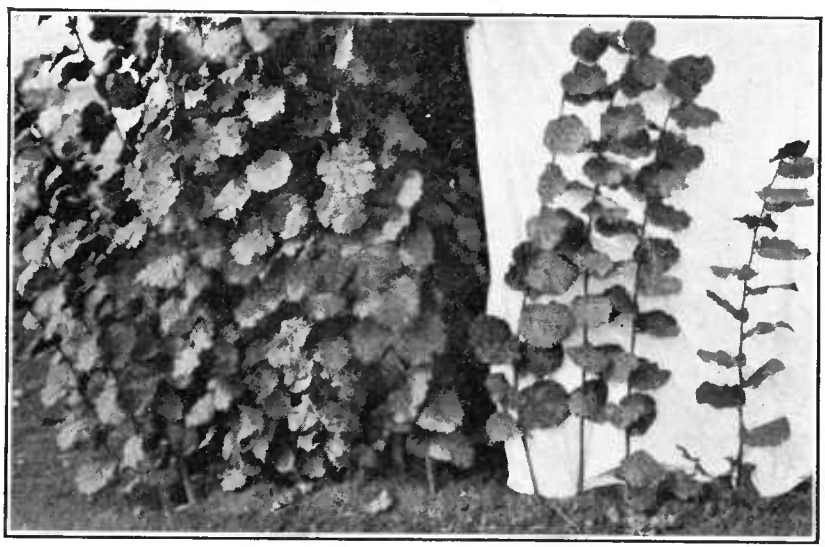

FIG. 2.—Healthy young filbert plants in September resulting from a sucker layered in early spring

quickly push out to form new terminals, each of which may be similarly layered during another year. The part that has been bent to the ground is covered with soil for a distance of several inches, leaving the end uncovered and in an upright position above ground. The terminal will continue to grow, forming the leader of the new plant, and at the same time roots will develop from the part under ground.

The plant shown in the figure was transplanted from the nursery in April, layered in August, and photographed in November. In this particular instance, the mother plant was to be used indefinitely and solely for propagation purposes. The young plant was later detached, transplanted in the nursery, and cared for during another year, when it was transferred to its permanent orchard position.

A somewhat different method of tip layering is shown in Figure 5. By this method suckers are layered in midsummer when the new shoots are tender and easily rooted, resulting in many more plants from a layer than propagation by the Gray method, as all of the laterals of a branch having new shoots are put in position for rooting. This system is occasionally practiced in this country, but it apparently has fewer advantages than the other methods described and certain disadvantages which are difficult to overcome: (1) It is practically impossible to hoe or to till the layered branches without injuring the young plants; and (2) the resulting plants are necessarily slower in developing, much less erect, and otherwise generally less desirable when grown.

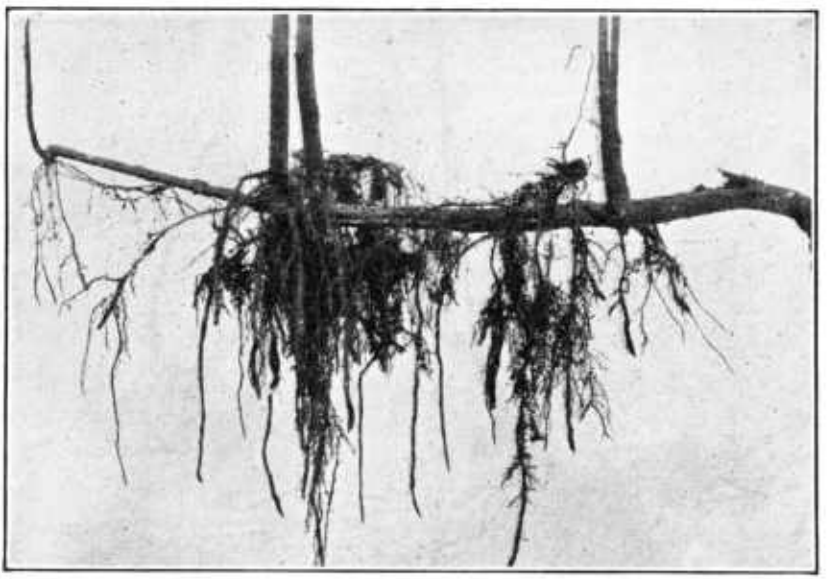

FIG. 3.—Typical root system of a filbert layer at the end of the first season following early spring layering

BUDDING AND GRAFTING

THE TWO PROCESSES COMPARED

The terms "budding" and "grafting" refer to different details of technic in accomplishing identical results. The common object of both is to transfer a part of one tree to another in such a way that the parts will unite and eventually form a new top for the tree to which the transfer is made. Strictly speaking, all methods by which this is accomplished are but different forms of grafting. In common usage, however, grafting is understood to mean the use of a section of stem from a branch of a large tree or of the main leader of a small tree; whereas budding means the use of but a small piece of bark with or without a piece of wood attached and with but a single bud. In grafting, the scion may have one or several buds.

Usually scions for grafting are of the previous season's growth, although those of older growth are often preferable. In most forms

of grafting, the scions are cut and used while dormant; but with certain systems more recently perfected they may be cut during the growing season and used at once if the leaves and new growth are removed. Growth proceeds from latent buds which have not started.

So far as the ultimate value of the mature tree is concerned, it is of little consequence whether it was budded or grafted in the nursery. During the early life of vigorous pecan orchard trees and under certain climatic conditions, however, there are often distinct advantages in favor of budded stock, particularly with reference to winter injury to the trunks, which has been very noticeable with the pecan in the East, both south and north. For a period of four to eight years, depending somewhat upon the

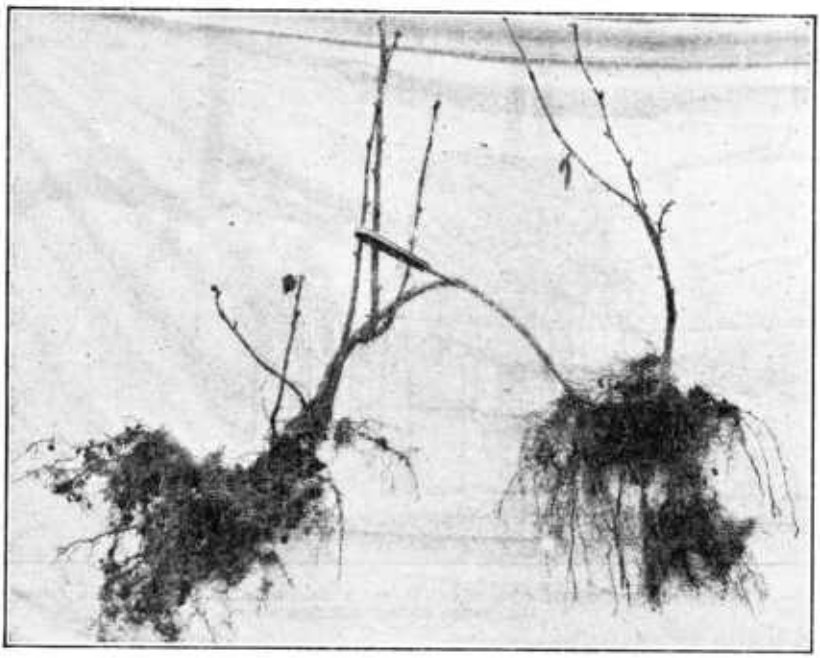

FIG. 4.—Filbert plant transplanted from the nursery in April, tip layered in August, and photographed in November

variety, the bark of the tree above the point of union (fig. 6) is likely to be smooth and largely without the natural protecting corky layer of the seedling stock below. Trunks of rapidly growing trees which have been propagated at the ground level or below and on which therefore this smooth bark extends almost to the ground are very subject to winter injury. This condition is particularly true on the southwest side of trees growing in the richer spots of sandy soil and invariably occurs immediately above the ground. As this seldom happens with trees that have been worked a foot or more above ground and as budded trees are usually worked at this height whereas grafted trees are nearly always worked below the surface, the advantage in favor of the former method is apparent.

The superiority of the budded pecan tree in this respect is regarded by many experienced planters as being so important that they refuse to buy grafted trees. On the other hand, low-grafted trees are strongly advocated by certain nurserymen of western Texas, who assert that trees grafted below ground are preferable under local conditions in that section, as most of the grafted trees develop roots above the union. It is possible that this theory is correct so far as that particular section is concerned, especially where the nursery pecan trees grow slower and the trunk becomes covered with a corky layer sooner than is the case farther east and for various other reasons is little affected by this particular form of winter injury. Moreover, it is not illogical to suspect that trees grown at least partially upon their own roots may have advantages over those entirely dependent upon the roots of other stocks, although with the pecan the extent of influence of the stock upon the scion is not yet well established. The development of

FIG. 5.—Stool of filbert tip layered in August and photographed immediately

roots above the unions of either walnut or hickory is so unusual an occurrence, however, that it is not to be counted upon. It would seem therefore, that in general the advantage is in favor of the budded tree.

Pecan nurserymen generally concede the greater susceptibility of the grafted tree to this particular form of winter injury, yet it is much to their advantage to give employment to labor in late winter when this method of propagation may be practiced and indirectly is an advantage to the purchaser, as the more economically labor can be employed the lower will be the necessary cost of the trees.

Budded pecan trees are distinctly preferable, however, and should be obtained for planting except under special conditions and when prices are the same. All grafted trees, especially if they grow rapidly, should be protected in winter by wrapping the trunks with burlap, heavy paper, several thicknesses of newspaper, or other ma-

terial, or shaded with rabbit veneer or some other kind of wooden material until the bark becomes thick and scaly.

Propagation of nut trees of species belonging to the botanical family Juglandaceæ is particularly difficult. With the first attempts of the amateur, success is more a matter of chance than of skill, as not infrequently propagators of long experience and recognized ability fail to obtain a successful stand of buds or grafts. The methods here outlined include the more common ones in general practice. It is neither expected nor desired that the detailed instructions will be followed arbitrarily, as each propagator must determine the method best adapted to his special conditions. Working independently and exercising ingenuity, he will soon develop an original technic peculiar to his individuality and to conditions under which he works. The implements to be used, style of cuts, methods of tying, or the kind of tying material will likewise differ from those of any other propagator.

FIG. 6.—Bark below and above a pecan union eight years after grafting, showing contrast. When pecan trees have been propagated near the ground, the smooth bark is brought low, subjecting the tree to the danger of a form of trunk injury which seldom affects parts with rough scales

THE SHIELD BUD

Propagation by the shield or T method of budding, so called after the form of chip removed from the bud stick and of the incision made in the bark of the stock, is practiced with various commercial species of nuts in this country, principally with the almond and to an increasing extent with the filbert. Ordinarily it is successful only with those varieties of species not difficult to reproduce by asexual methods. In general nursery practice it is the most common system employed with the stone fruits, to which group the almond belongs.

A short horizontal cut is first made in the bark midway between the buds or branches at a point where the stock is not more than an inch in diameter. From the under side of this cut, midway between the ends and extending directly downward, an incision an inch or more in length is made, thus completing the T. The bark at the upper end and on the two sides of the downward cut is lifted slightly and turned aside. The bud, in the form of a shield a half inch or more in length, is then taken from a freshly cut bud stick of the current season's growth, to which will be attached a thin

slice of wood directly beneath. The bud and its chip are removed by making a long downward, shallow and straight cut from above the bud, directly under it to a point immediately below, from which the knife is brought to the surface. If the wood is inclined to be weak, the chip should be trimmed off sharply, particularly at the lower end, in order to lessen the danger of its doubling up when pushed into place. It is then inserted in the vertical cut on the stock, pushed under the bark, splitting it open as it goes, far enough for the bark to be brought together above the bud and tied securely with raffia or some similar material in much the same manner as in chip or patch budding. The season for propagation by this method is in middle and late summer after the new growth has become somewhat firm. A fuller description of this method as ordinarily practiced appears in Farmers' Bulletin No. 157, page 14.

A form of shield budding the pecan developed by C. L. Edwards, of Dallas, Tex., has been found very successful in that State and pertains to cutting the bud chip from the scion rather than to a different way of handling the stock. By the Edwards method the bark of the bud stick immediately above the bud is cut horizontally across and the bud removed by inserting the knife under the bark directly below the bud and drawing it up to the horizontal cut. The lower end of the chip is then cut on the two edges in such a manner as to give it a rather bluntly pointed V-shaped chisel edge. It is then inserted in the vertical slit in the bark of the stock. Subsequent treatment is the same as for any other method of budding.

Mr. Edwards regards this method of budding the pecan as the simplest of any yet perfected. He points out that while chip buds require a snug fit all around, the shield form needs only to be closely fitted at the upper end and kept straight with the grain of the wood when inserted under the bark of the stock. The season for using this kind of bud is after the bark of the stock begins to slip and while dormant buds may still be used. A disadvantage which Mr. Edwards cites is that when wet weather sets in before the buds have started sap sometimes gathers in the slit at the lower end of the buds, causing them to fail.

So far as known, this system of propagation has not been practiced by many pecan growers, but it nevertheless appears to have possibilities abundantly justifying its serious study.

INARCHING

The method of propagating nut trees by inarching is more certain to give eventual success than any other known form of grafting. It is easy to effect and reduces to practically an absolute minimum the risk of losing either the stock or the scion, but it is ordinarily infeasible because it involves considerable time for successful accomplishment. The procedure is as follows: Parts of two trees are brought together, the bark of each on the facing side is pared away, and the two are bound tightly together (fig. 7). Both stock and scion are then coated with wax or paraffin, unless previously bound with strips of waxed cloth; or they may be left merely tied together. When a union has successfully formed, the top of the stock is pruned away, the bottom of the scion severed, and the operation is complete.

Obviously, the extent to which this method can be employed is necessarily limited, as it is seldom that trees can be brought sufficiently close together to be grafted. It is of special utility in the inarching of small cross branches of different limbs on the same tree, thus forming natural braces to overcome forked crotches, as in the apple tree shown in Figure 8. Figure 9 shows how inarching was ingeniously used by J. C. Cooper, of McMinnville, Oreg., in developing a street tree. Two black-walnut seeds had been planted where one grafted Persian (English) walnut was desired. As soon as one of the resulting seedlings was of sufficient size for grafting, a scion was inserted. When the success of the operation became assured, the weaker seedling was inarched into the grafted tree below the union, resulting in one top of Persian walnut with two stocks. Although the purpose of inarching in this instance was primarily to dispose of the weaker tree, it actually resulted in added nourishment to the single top, as is shown by the greater diameter of the other tree above the point of inarching. The plan afforded an easy disposition of the weaker tree.

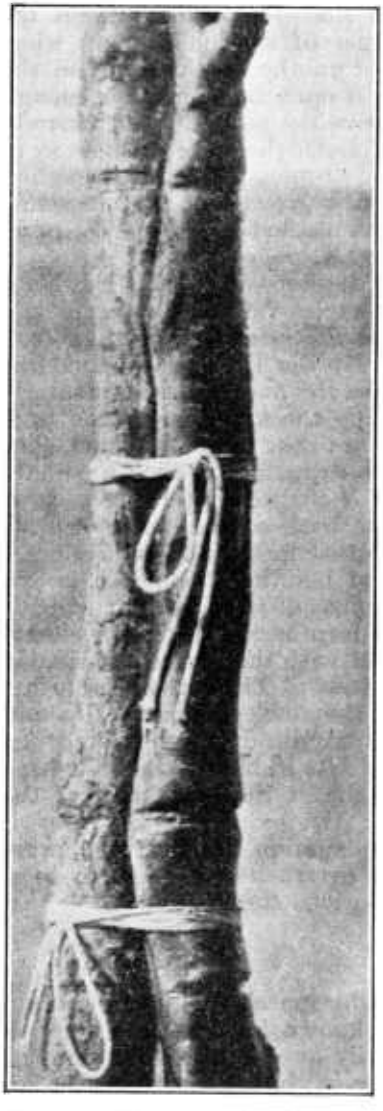

FIG. 7.—Inarching or grafting by the approach method

Inarching of a slightly different form is occasionally found successful in grafting nut trees near the ground. The stock is cut off about 6 inches above ground and given a downward cut to one side of the center as in cleft grafting, the knife being held at an angle of about 45°. A scion is put in place by fixing the lower end firmly in the ground for the purpose of taking root, and the upper part is inserted in the cleft of the stock a few inches below the tip, at which point the two sides are pared away in such manner that the cambium layers of the stock and scion may be brought closely together. Subsequent steps are the same as in other forms of grafting.

A Stuart pecan scion grafted in this manner by B. M. Young, of Morgan City, La., during the early nineties soon developed its own roots, which grew vigorously, first to the disadvantage and later to the complete elimination of the original roots of the stock. The

scion thus became a rooted cutting and the tree one grown upon its own roots.

By bridge grafting, inarching may be made to overcome wounds or winter-injured spots on the trunks of large trees. Fresh scions, preferably without buds, may be inlaid closely together in such a way as to span the wound, and with careful workmanship performed at the right time success will be practically certain and recovery swift. The scions should be sharpened at each end and the bark on the sides cut away with a plane. The importance of this method in

FIG. 8.—Brace limbs formed by the inarch method, used to overcome forks in the head of a tree

overcoming ugly wounds in tree trunks, particularly those caused by harrows, can scarcely be overestimated and should be seriously considered as a very practical means of combating the inevitable heart rot following such injury. This method is more fully described in Farmers' Bulletin No. 1369, entitled "Bridge Grafting."

ANNULAR BUDDING

During the early period of pecan propagation it was a common practice to transfer a complete ring of bark with the bud from the

bud stick to the stock (fig. 10) by what was variously known as the annular, ring, or flute method. This method is highly successful when properly performed; but experience early demonstrated that a complete ring is hard to transfer successfully, because of the difficulty in obtaining bud sticks and stocks of the same size and the consequent danger to the life of the buds through unavoidable delays involved in effecting a good mechanical fit. Also, it was found that complete rings of bark were unnecessary, as part rings or patches fully met the requirements and were more easily transferred. The full annular method has therefore been almost wholly superseded by various modified forms of this system. For beginners, however, it is a method well worth mastering and may be employed during a long period of time.

FIG. 9.—Inarching of a weak black walnut seedling into a stronger one near it which had been successfully grafted to Persian walnut

By using dormant scions taken from storage long enough beforehand for the bark to loosen, the season will begin as soon as the bark on the stock first slips. Buds from the new growth may be used as soon as they are sufficiently mature. With the pecan in the South this stage usually begins in July and continues until the end of the season. Hewett Joiner, of Oglethorpe, Ga., reports that in his section excellent results are being obtained by using buds from sticks cut just as the sap first flows enough to start the bark. Though the season lasts but a few days, he states that the percentage of success is very high.

PATCH BUDDING

The patch bud is the principal form of modified annular propagation in use. It is extensively practiced with the pecan in the South and to a considerable extent with various kinds of nut trees in the North. It is not common on the western coast. It can be employed only during the active growing period of summer, when the sap is flowing at moderate rate. Too free a flow of sap causes the bud to "drown," and too little will result in its drying up without "taking." Successive steps in the operation, as shown in the title-page illustrations, are as follows:

(*a*) Some time during the summer, while the bark of the stock is found to slip freely, two parallel transverse cuts from three-fourths inch to one and one-fourth inches apart are made with a thin-bladed sharp knife or a specially designed tool similar to those illustrated in Figure 11, about one-third or half-

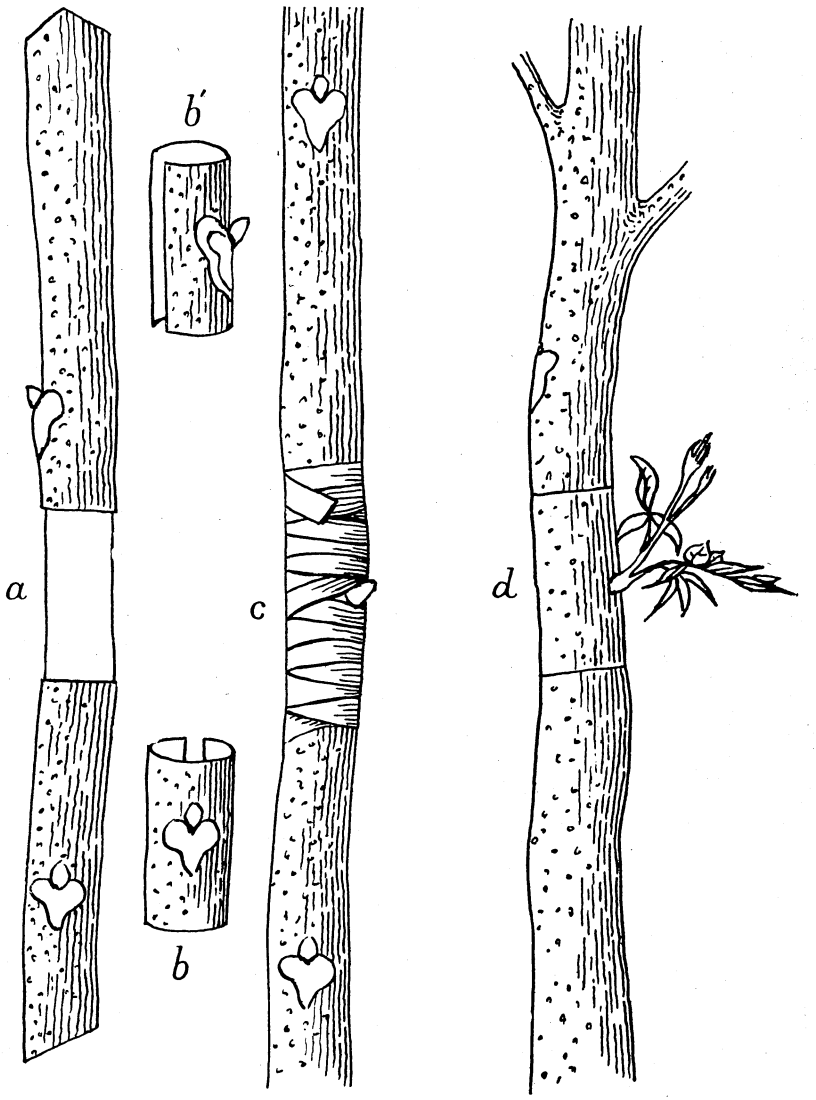

FIG. 10.—Successive steps in budding by the annular method: *a*, The bud stick after removal of the bud; *b*, *b'*, front and side views of the bud; *c*, the bud in place on the stock after being wrapped with a half-inch strip of waxed cloth; *d*, the bud starting into growth after the cloth has been removed

way around the trunk, preferably at a point where the stock is an inch or more in diameter.

(*b*) With a single blade a vertical slit is made on the right to connect the ends of the two horizontal cuts. The bark is then lifted on the left of the vertical cut and peeled to the operator's left, where it is held without being completely severed.

(*c*) The bud is removed from the bud stick in a similar manner, taking with it a rectangular piece of bark, and quickly put into the exposed place on the stock, or "matrix," as it is called.

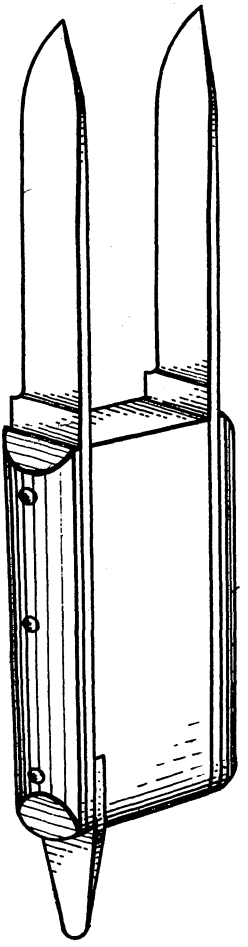

FIG. 11.—Budding knife with a double blade used in the annular method of budding and in some of its modified forms. In annular budding, two parallel cuts are made with this knife part way around the stock, after which one vertical cut is made connecting the transverse cuts, and the entire ring of bark is removed by being lifted with the short stub at the end of the handle. In patch budding, two parallel vertical cuts are made, using one knife blade only

(*d*) While the bud is held firmly in place, the bark of the stock is laid back over its surface and carefully pared away in such a manner as to cause it to fit snugly on all sides. The bud is then wound securely with a quarter-inch strip of waxed cloth, beginning below and winding upward so as to leave the surface in shingle fashion, but with the bud itself exposed. As soon as the bud has united firmly with the stock, the top of the latter should be removed down to a point about a foot above the bud, leaving a stub for later use as a support to which to tie the new growth.

(*e*) At intervals of a week or 10 days the tying material should be unwound and reapplied to allow for expansion owing to growth without choking. In retying, the strings should not be applied in the same place as before or they will form deep grooves in the bark. All growth from the stock should be pinched off.

(*f*) As soon as the cuts are entirely healed the tying material should be removed. Shortly thereafter the upward growth from the scion should be tied loosely to the stub of the stock above for the remainder of the growing season. At the beginning of the following spring the stub should be removed by making a sloping cut close above the bud and providing such support as may be needed by a straight stake driven in the ground.

Instead of using an implement of the type illustrated in Figure 11 some operators prefer a tool like the one shown in Figure 12, by which the cuts on all sides of the bud are made at once. This tool simplifies the matter of obtaining a fairly snug fit, yet the thickness of the blades in pressing back the bark as the cuts are made prevents an absolute fit. Nevertheless, with favorable conditions of growth in both stock and scion, careful workmanship should result in the success of the operation.

J. F. Jones, of Lancaster, Pa., discovered that by making the cuts in the stock from one to three weeks before the bark is removed the percentage of successful unions will be materially increased, for by so doing healthy repair tissue begins to form by the time the bud is inserted. The danger of excess sap is also thus eliminated, and certain small insects which frequently work under the bud patch are prevented from gaining entrance.

The rate at which this tissue will develop varies greatly with growing conditions of the stock at the particular time. In Figure 13 this rate is illustrated in one instance with pecan stocks. The photographs were made in midsummer at intervals ranging from 4 to 27

days. In this case it was found that the greater period was not too long. Mr. Jones regards this practice as of such importance that it is followed in all of his nut-tree budding.

Bud sticks for use in patch budding should be in such condition of growth that the buds may be easily removed. If a tool such as that shown in Figure 11 has been used in making the cuts about the bud, the piece of bark to which the bud is attached, if in proper condition of sap flow, may be removed by holding tightly and by twisting in the fingers while the stick is gently yet firmly manipulated with the other hand. The bark with the bud attached should be lifted without splitting. Care should be taken lest the bark come loose, leaving the bud attached to the stick.

Stocks for use in patch budding should be approximately the size of a man's thumb at the point where worked, although either larger or smaller sizes may be used. By paring away the thick, scaly bark, buds may be inserted in fairly old trunks or branches. The most readily worked trees are the vigorous growers usually found in the rows of well-cared-for nurseries during the summer of the second year after the seed has been planted. With the pecan, trees budded when the stocks are of this size should become suitable for transplanting at the end of the following year, thus making the stock 3 years of age by the time the tree is ready for orchard planting.

In top-working, the patch bud is ordinarily used during the late summer of the year in which the tree was cut back in early spring or late winter. The subsequent care is much the same in top-working as in nursery work. With late-growing stocks the patch method may be employed until late autumn.

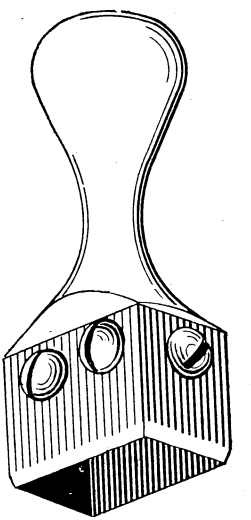

FIG. 12.—A metal tool specially designed for use in patch budding

CHIP BUDDING

A method of propagation known as chip, or dormant, budding, because of the character of the bud used and the season when it is performed, is perhaps the most common one practiced with pecans in some sections of the South. The successive steps essential for this method of propagation, as illustrated in Figure 14, are as follows:

Using a sharp single-bladed knife, held horizontally (*a*), make a very short cut sloping downward and inward in the bark of the stock at a smooth place between the buds, penetrating through the bark and slightly into the wood.

With the knife still held horizontally an inch or more directly above this cut make a new cut at a long downward angle, first through the bark into the wood, then straight downward to the bottom of the lower cut, to remove a chip (*b*).

Remove the bud from the bud stock in the same manner, making the first cut below the bud and the second cut above.

Slip the bud into the matrix (*c*) so as to make a close fit.

With the bud snugly in place, cover it with a rectangular piece of waxed cloth 1½ inches wide and 2 inches long, with a large nail hole in the center through which the bud is made to protrude (*d*). Press the cloth down firmly; the warmth of the hand will cause the wax in the cloth to soften slightly.

When properly applied this cloth will make a covering practically impervious to water.

Wind the waxed cloth with raffia (*e*), making it permanently secure (*f*).

Subsequent steps are the same as for patch budding.

Chip budding may be begun soon after the sap begins to flow and may continue until the first leaves are half grown. Best results are usual at about the time the buds are bursting into leaf or when in the condition shown in the figure. In northern Louisiana the period during which the chip method is practiced extends from the last of March until after the middle of April, varying somewhat with the season from year to year. It is particularly important that the scions be entirely dormant.

The method of chip budding has three distinct advantages. In nursery practice, the season fits in very well between those of whip grafting and patch budding, thus prolonging the propagating season and making it possible to keep labor more constantly employed. Early budding in this way provides a long season for growth. Vigorously growing trees so budded usually become of transplanting size

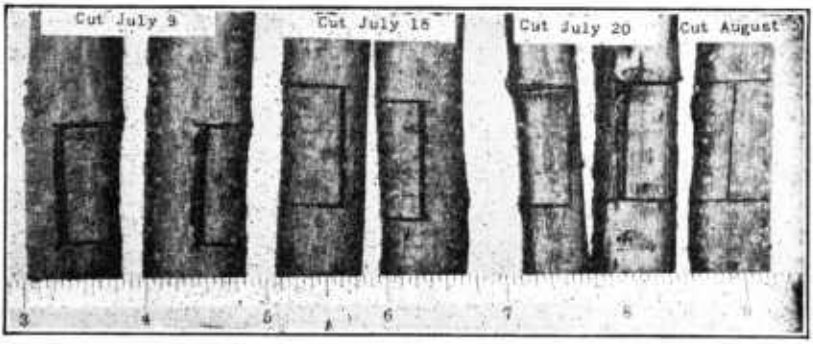

FIG. 13.—Calluses resulting from cuts in pecan stocks made 28, 21, and 17 days, respectively, before being photographed. By making advance cuts in this way calluses soon form, and the percentage of success in budding is materially increased. The last cut was made on the day the photograph was taken, August 5

by the end of the season. Like patch budding, the system injures the stock but little, and if failures occur some other method may be used. On the other hand, however, the system does not give uniformly good results in different sections of the country. Theoretically its field of usefulness should be very large. Actually it has been much limited, and its extensive use in the future now appears improbable, not because of any defect in the system but because other methods have chanced to receive more attention at the hands of propagators and are therefore better understood.

CROWN BUDDING

Crown budding is a system of propagation resembling both chip budding and what is later described in this bulletin as "Bark grafting," developed by C. L. Edwards, of Dallas, Tex., as a joint modification of the chip and shield methods. He discovered that with dormant scions which have begun to swell it is often possible to obtain a considerably higher percentage of success by this method than with other forms commonly employed at that season.

The first step in this process is to cut off the stock a foot or more above the ground at a slope, the same as for grafting by the slip-bark method. A vertical slit about 1 inch long is then made on the higher side of the stock, opening the bark slightly at the upper end. The bud is cut and inserted in the same manner as for a shield bud, as heretofore described (p. 8). Subsequent care is the same as for other forms of budding.

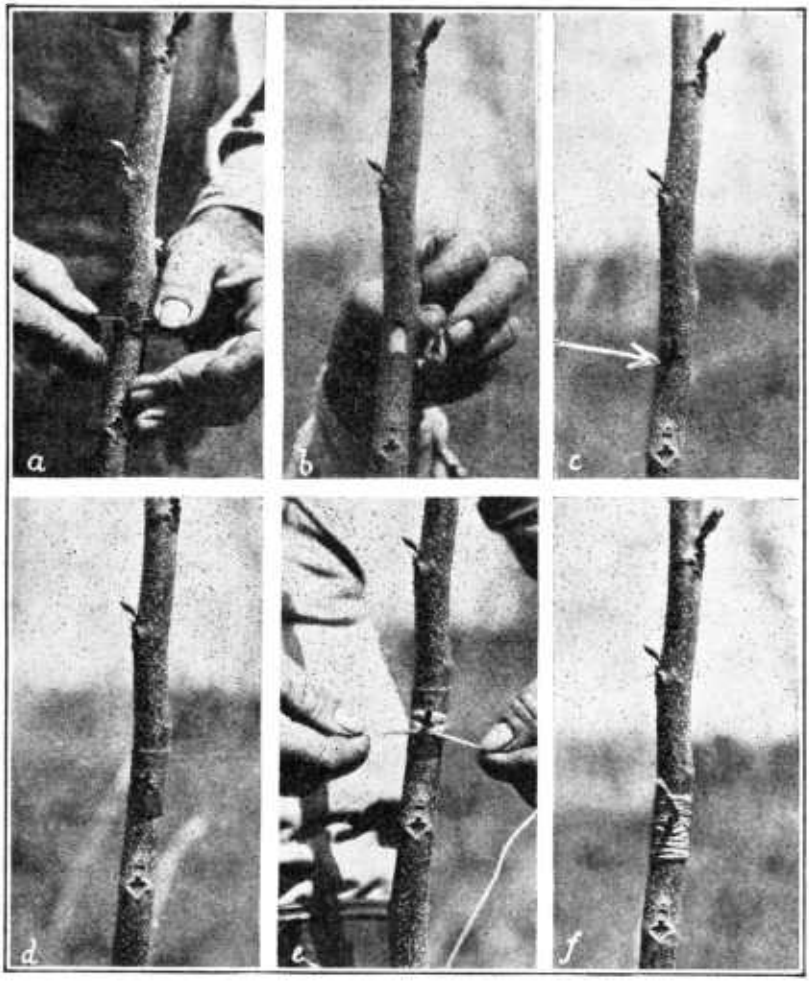

FIG. 14.—Successive steps in chip budding

In addition to the particular advantage of this method already cited, Mr. Edwards finds that bud scions smaller than for chip budding may be used, and that in northern Texas the season for propagation is made to last from the beginning of the sap flow until about the middle of August. He finds it particularly useful in propagating nursery seedlings which for any reason have outgrown the size most suitable for whip grafting or for budding by either the

patch or the chip method. In his experience it has been highly useful in top-working small trees large enough to have branches.

The crown method of budding is not in general use. So far as known to the writer, it has not been practiced elsewhere than in eastern Texas. It affords further evidence that there are but few occasions during the growing period when one or more systems of pecan propagation can not successfully be employed and that men of ingenuity are constantly devising improved methods.

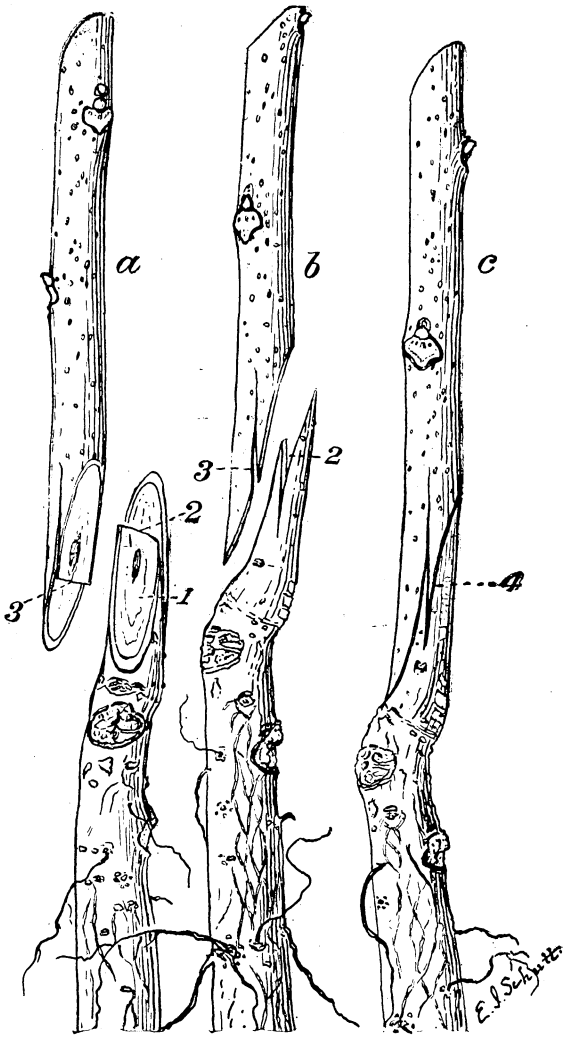

FIG. 15.—Splice grafting. Successive steps in the operation: *a* and *b*, Front and side views of both stock and scion carefully cut; *c*, stock and scion after being securely and properly fitted together; 1, 2, 3, and 4, views of the tongues of both stock and scion

SPLICE GRAFTING

The method of splice grafting, often called "whip grafting," illustrated in Figure 15, is extensively used with the Persian walnut in the West and the pecan in the South. Thrifty 1-year-old seedlings in nursery rows are grafted by this method during the late winter months.

A general view of a crew at work in a pecan nursery during February is shown in Figure 16. The soil is first plowed away from each side of the row to a depth of 6 inches, and that between the trees is pulled away with a hand potato digger or hoe. Following this operation a laborer removes the soil from the immediate base of the seedling by hand, leaving each tree cleanly exposed to the desired depth and ready for the grafting crew.

Dormant scions from storage in lengths having at least two good buds each are cut an hour or so beforehand, by another crew working in the packing house, and tied in 6-inch bundles. A knife like one of the two illustrated in Figure 11 and an oilstone to keep the

knife sharp are essential. The operator makes a long diagonal cut through the stock by drawing the knife upward and toward himself from the opposite side. (Fig. 17.) Both stock and scion are given "tongues" by making short, lengthwise cuts down the stock from midway above the pith and up the scion from midway below the pith, and the two pieces are pushed together as illustrated at *c* in Figure 15. The alignment of the cuts should not be parallel, but both should be toward and across the pith.

In grafting the Persian walnut, according to Batchelor,[2] the union is waxed but not tied. With the pecan, the union is tied securely with raffia by a helper who follows closely behind the propagator. With both the walnut and the pecan, soil is then worked back around

FIG. 16.—Splice grafting pecan trees in the nursery

the scion and over its top to a depth of 1 or 2 inches. Neither wax nor raffia will interfere with the growth expansion of the stock as the wax is easily pressed aside and the raffia quickly disintegrates.

Under favorable conditions of growth the trees should develop rapidly and become merchantable by the end of the season. Walnuts should range from 6 to 10 feet in height and pecans in the Southeast from 4 to 10 feet, depending largely upon the variety and season. Pecan trees in the Southwest grow less rapidly, the usual size being from 3 to 7 feet.

In the North, where the growing period is short, no effort is made to graft under ground. Much the same method is often employed, but the unions are effected at 3 to 6 inches above ground. Stout string, raffia, or strips of waxed cloth are used in tying, after which

[2] Batchelor, L. D. Walnut culture in California. Calif. Agr. Exp. Sta. Bul. 379, p. 34. 1924.

melted wax or paraffin is applied over all surfaces, including the end of the stock and the whole of the scion. When the latter is not coated it is well to put a paper sack over all, as shown in Figure 18. When the new growth begins to push against the sacks, they should be torn open and soon removed entirely. The wrapping material about the stock should be unwound and reapplied as may become necessary to allow for expansion and yet provide security.

TOP-WORKING NUT TREES

Over much of the country top-working offers the most inexpensive and quickest available means of bringing nut trees into bearing. The possibility of converting, without injury, an unfruitful nut tree into one which may soon yield a crop of highly palatable human

FIG. 17.—Operation of splice grafting in the nursery

food is something well worth considering. At small initial expense, the energies of nut trees are often made to give returns which may be moderate or even small but will go a long way toward meeting payments on taxes, interest, household expenses, or other indebtedness, or which may be highly profitable.

Much the same methods of effecting unions as are employed in the nursery are used in top-working large trees; and as it is almost inevitable that sooner or later every orchard or grove owner of any considerable experience will have a certain percentage of trees to be converted into more profitable varieties, he should be able to perform at least one method successfully. With a working knowledge of one or more methods of propagation, the owner may replace the tops either of inferior varieties in the orchard or of seedlings in the

fields, along the fence rows, or on the highways with scions which will quickly develop into profitable tops.

The process of top-working involves three very distinct and equally important operations: (1) The removal of the present top, (2) the grafting (or budding) of scions in place of the branches cut away, and (3) intelligent care for the new tops. With trees of proper size it is possible to have new tops come into bearing during the second or third year. Not infrequently the size of the new top will equal in five years the growth which the trees would have had in the same time had no cutting been performed, and full crops may be looked for shortly thereafter. In this way trees which are partially or wholly nonproductive are often made to become valuable assets. Even the species may be transformed, as when the Persian walnut is grafted upon the inferior black walnut of the western coast, or the pecan upon a less valuable hickory (though this is seldom to be recommended), a shagbark hickory upon a mockernut,

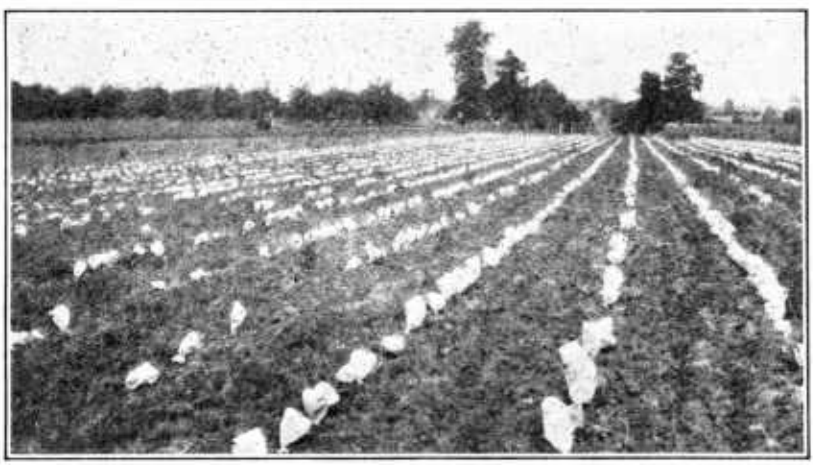

FIG. 18.—Paper sacks over Persian-walnut scions in an eastern nursery after being grafted in April by the cleft method

or a choice variety of *Pistacia vera* upon the more ornate and hardier yet less fruitful *P. chinensis*.

SUITABLE SIZE OF TREE

Theoretically it is possible to top-work trees of nearly any size or age. In practice, however, it is well to use only those under 40 feet in height and not more than 30 years old. Best results are to be looked for with vigorous-growing young trees ranging from 25 feet down to 6 or 8 feet. They should be symmetrically branched and with heads not more than 5 or 6 feet high. Low branches can seldom be made to develop on shaded parts of a tree, and when in crowded orchards (fig. 19) or wild groves all neighbor trees should be removed to a minimum distance of 60 feet. Trees having but a single leader or those with several main branches may be used. Figure 20 illustrates a well-worked tree of the former type about 40 feet tall, on which 42 scions were grafted two years before the picture was

taken. This may be accepted as a good model of a top-worked tree of the single-leader type.

Objections to using large trees lie principally in the shock to the tree when large cuts are made (fig. 21) and in the physical difficulty of performing the operation when severe dehorning is not employed as a means of bringing the point to be grafted to within the reach of ladders. The tree illustrated was cut back in

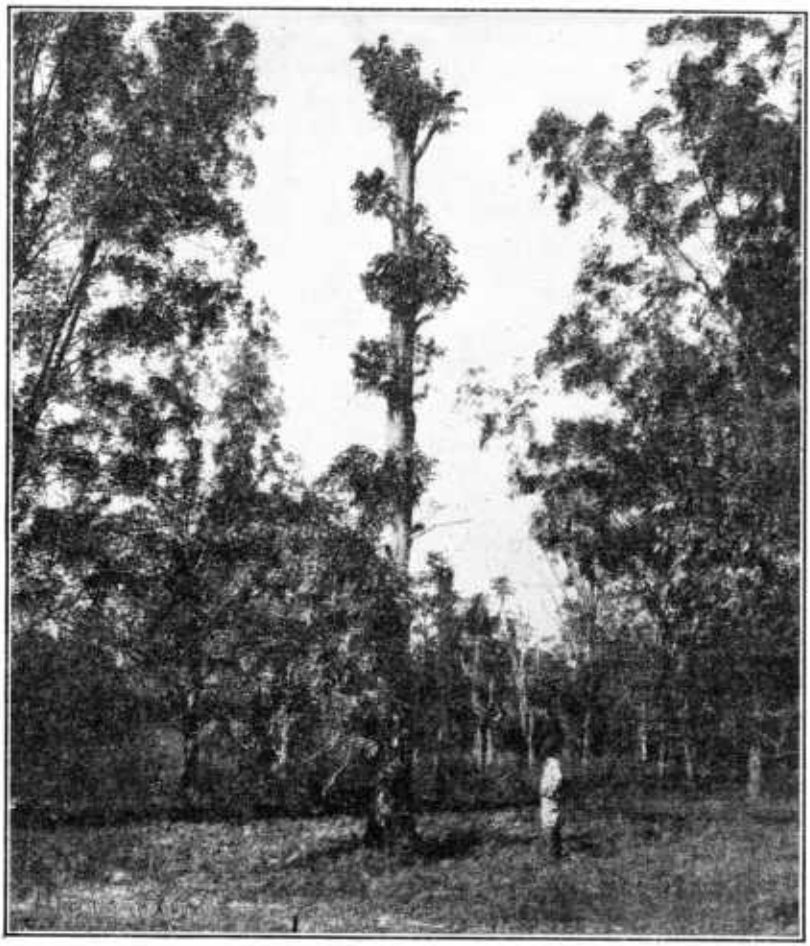

FIG. 19.—A single-leader type of pecan tree in a crowded orchard in process of being top-worked

late winter. Toward the end of March the force of sap, with its natural channels obstructed, burst open the bark, and the sap escaped to the outside, where it fermented and caused a conspicuous froth. Sometimes in such cases the sap wets the side of the tree, but the bark soon dries out, and invariably the spot is attacked by shot-hole borers. In severe cases the trees lose their bark on the affected area and either recover slowly or eventually succumb. Trees badly wounded by such cuts seldom if ever fully recover.

MAKING PREPARATORY CUTS

Whenever possible, trees should be top-worked on the branches rather than on trunks which have been cut off abruptly. In order to minimize the shock to the tree and to provide opportunity for further grafting should the first grafts fail, thus rendering the stubs unfit for subsequent use, a few small branches distributed throughout the trees should be left uncut, as shown in Figure 22. These branches should be watched closely during the entire first season lest they draw too much sap away from the grafts and interfere with

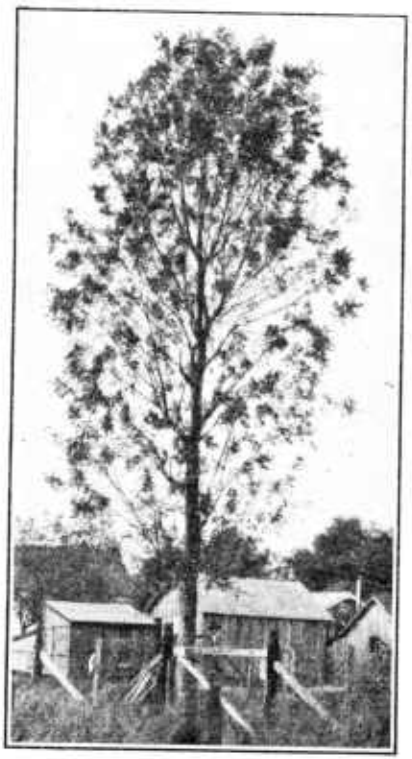

FIG. 20.—A seedling pecan tree of the single-leader type two years after being properly top-worked. Use was made of 42 scions, although the tree was less than 45 feet in height

FIG. 21.—Pecan tree, showing disastrous results two years after being topped too severely preparatory to budding or grafting

the desired growth. They should be cut back in part or entirely, as may be necessary, so that the grafts may receive a proper share of sap. The insertion of several grafts obviously makes success more certain than to insert but one. With high-headed trees which have been crowded while growing it may be necessary to cut off the entire top in order to bring the new top to within convenient reach. When severe cutting can not be avoided, the cuts should be made at a sloping angle (fig. 23), and several scions may be inserted on the higher sides of such cuts. When a single scion is inserted, especially with large stocks, the new growth is in danger of being weak and unless supported is easily broken off, as shown in the illustration.

However, irrespective of whether such growth can be prevented from breaking, it is less desirable than that which is slower and more stocky. Several scions should be inserted in large stocks and later thinned out when crowding begins. Rank-growing shoots should be headed back in summer or supported by stakes in the ground or by parallel cleats tacked lengthwise to the limbs.

These cuts should usually be made in late winter or early spring, before the sap begins to flow. Later cutting is difficult to perform without splitting the bark of the stock or knocking off the bursting buds and new shoots. In early spring when the sap is flowing freely it is impossible to climb rapidly growing young trees with-

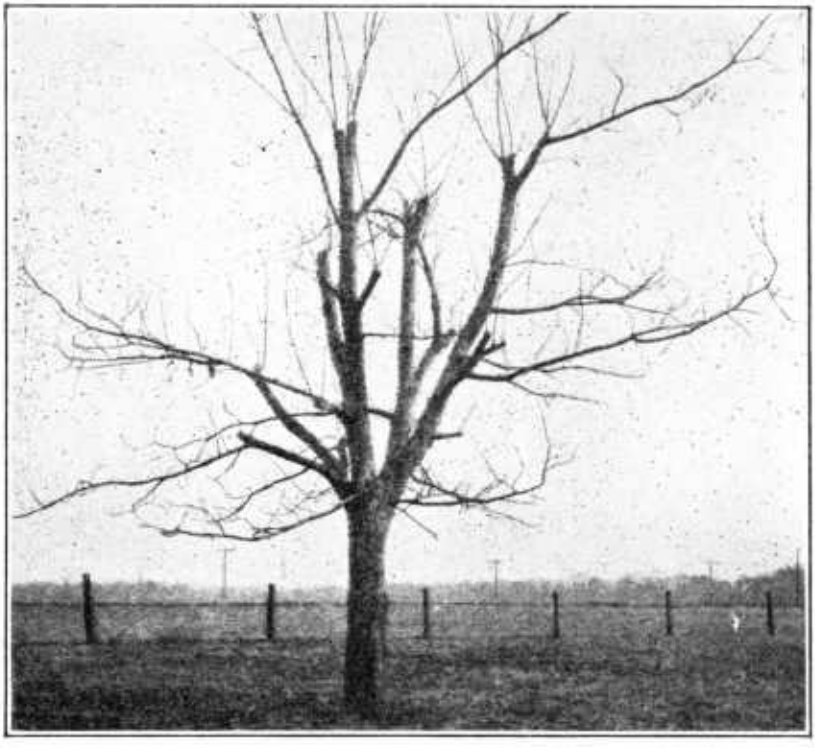

FIG. 22.—An orchard pecan seedling of the open-headed type during the period of transformation by top-working. Photographed at the beginning of the second year, immediately before the remaining seedling branches were removed

out causing bad and wholly unnecessary bruises. For immediate grafting by the cleft method or some modification of it, or for grafting in early spring, the cutting may be performed just preceding the operation. It is, however, a part of the operation of top-working which may be attended to early in the season on days too cold and disagreeable for grafting. All trees to be so worked should be dehorned at least a day or two ahead of time and the branches dropped to the ground and hauled away. The grafting can then proceed with a minimum of hindrances.

Adult trees when successfully top-worked and given proper subsequent care should again assume normal tops within five or six years.

An orchard of pecan trees photographed at the beginning of the sixth year after having been so top-worked and cared for is illustrated in Figure 24. The new tops were of a prolific variety and had borne a fair crop during the previous season.

Whenever possible, no cuts should be made at points where the diameter of the stock is more than 3 inches, preferably not more than 2 inches. Figure 25 illustrates an apparently successful job of top-working a roadside row of California black-walnut trees with scions of a standard variety of Persian walnut. Close inspection of the trees at the time the photograph was taken, however, revealed the fact that the preparatory cuts had been unduly large and that nearly every tree contained a large lesion of heart-rot in the center. Such decay once started is practically impossible to check, although except in very bad cases it is usually engulfed by subsequent growth.

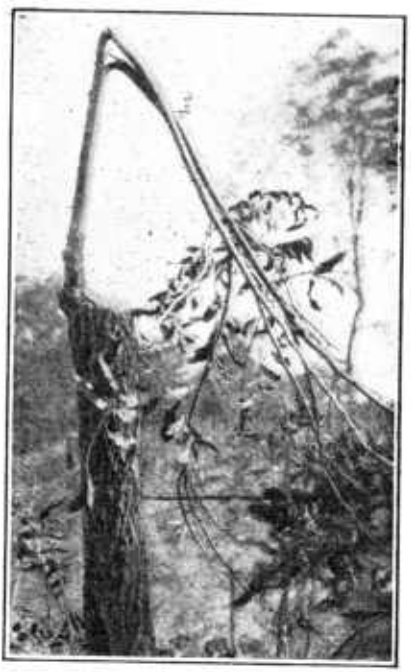

FIG. 23.—Growth from a single scion on a large stock. Such growths are often unable to support their own weight during the first season. Several scions should be inserted and weak growth supported by stakes in the ground or cleats tacked to the trunk. When these precautions are not taken, rank shoots should be headed back in summer. The stock is that of the mockernut hickory

At Ardmore, Okla., it has been found practicable under some conditions to cut the trees to be grafted close to the ground. The tree shown in Figure 26 was thus cut in February. The resultant sprouts were budded in August and photographed in November. The tree was in a forest of mixed timber. The entire tract was cleared, and in spring the sprouts from all but the pecan stumps were grubbed down. In this instance two buds were inserted, one on each sprout. Of these, one bud pushed forth immediately, but the other remained dormant until the following spring. A general view of this grove, illustrating the spacing and height of growth, is shown in Figure 27.

A practical question arising from this kind of work is, what will become of the stump and to what extent will it decay and cause destruction to the new tree? The answer need not occasion grave alarm, although it is certain that considerable decay will be inevitable. At present much of the standing timber in American forests consists of trees of this kind, technically known as coppice.

What is of more importance is the greater length of time required for the trees to come into nut bearing when this method is pursued than when top-working is employed. The root system of a tree quickly adjusts itself to the top with which it is connected. In a short time after a tree has been cut to the ground the roots become largely proportionate to the size and capacity of the sprouts. There-

fore, the sprout does not have the full benefit of a mature root system, but, practically speaking, will have little more than that of a young tree. Consequently, it will be several years longer in beginning to bear.

These sprouts, however, will be easier to bud or graft, the resulting trees will be more uniform, and the new tops will be more accessible from the ground. When trees are to be worked in this way, several sprouts should be allowed to grow from the sides of the stump; the strongest should be grafted or budded and all others inarched into it by the method illustrated in Figure 9. In this way the new growth will completely cover the stumps and be so securely braced that danger of blowing out will be reduced to a minimum.

FIG. 24.—Top-worked pecan trees six years after the operation. They bore well during the fourth year

BARK GRAFTING

During recent years certain leading experimenters, notably Robert T. Morris,[3] of New York, C. R. Biederman, of Arizona, and the late E. A. Riehl, of Illinois, have developed marked improvements in a method of propagation long known as crown or bark grafting. Discoveries made by these men and others have so perfected the system that in top-working, some form of bark grafting, temporarily at least, over much of the country, has largely supplanted the once more common cleft-graft method. This new method differs from the latter principally in that it is practised while the bark slips, or during what is commonly regarded as the budding period; the wood of the stock is neither split nor cut vertically, and dormant scions are not essential. Grafting by this method may be performed after the cold, unpleasant days are over and the mild weather of spring and early summer has begun. The scions may be cut and used immedi-

[3] Morris, R. T. Nut growing, 236 pp., illus. New York. 1921.

ately, but best results are to be expected with scions cut while dormant and held in storage for later use.

The Morris method.—Morris found it possible to graft nut trees successfully by inserting scions well down on the side of the tree trunk, using a sharp carpenter's chisel and a heavy wooden mallet with which to make the incisions in the thick, coarse bark. He has termed this method the "proximal" graft because of its being employed at almost any point on a limb or trunk that is proximately situated near the ground at a desired point. The top, of course, is removed later. A proximal graft made by Arthur Best, of Lancaster, Pa., is shown in Figure 28. By grafting in this way, branches may be made to form at almost any desired point. The system is especially useful in high-headed trees, or with those having long sections between branches. It would perhaps be well, however, to use this method somewhat cautiously, for although it is possible to make successful unions by the proximal graft, the problem of caring

FIG. 25.—Highway row of California black-walnut trees top-worked to Persian walnut

for the large wound certain to be involved when the top of the stock is removed will be one not easily solved. The subject of wounds has been discussed under "Making preparatory cuts" (p. 23). This method is sometimes practiced in the nursery, but by most nurserymen some other is preferred.

Another form of bark grafting, called by Morris the "distal slot graft" because of its being employed at the distal ends of cut stocks, has been highly successful. By the use of this method many propagators who previously were unable to effect successful grafts by the more common methods are now meeting with encouraging results. It is a method which all amateurs should learn until some better means of propagation is perfected. Instead of bark grafting, Morris now prefers to divide a limb close to a small twig. This small twig and others on the limb are then given an ordinary cleft or splice graft, thus obviating the tendency of the bark graft to blow out when a strong wind strikes a rank scion growth. The cut end of the

limb is then covered with melted paraffin or tree paint, to protect it against decay.

O. J. Wenzel, manager of the Southern Pecan Growers' Association, Albany, Ga., and E. R. Lake, of the United States Department of Agriculture, have been particularly successful in the use of distal slot grafting, the former having devoted considerable time to its commercial use during each of the past several seasons. The illustrations shown in Figures 29, 30, 31, 32, 33, and 34 are after the Morris method as modified by Wenzel and relate to top-working pecan trees. Figure 35 is also after the Morris method, but as modified by Lake, and represents a nursery-grafted black-walnut tree. It will be noted that Lake makes a long slot in the stock, whereas Wenzel makes a short one. The longer slot forms a much stronger mechanical union.

FIG. 26.—Sprouts from a pecan tree in Oklahoma cut to the ground in February, budded in August and photographed in November

The operation of distal slot grafting as now practiced begins with the cutting of the stock, preferably at a point not more than 2 inches in diameter, while the tree is still dormant or practically so. With pecan trees in southwestern Georgia, this will be at any time after midwinter. The best results are obtained by cutting two or three weeks before the grafts are to be inserted. The cuts are made at a sloping angle, as shown in Figure 36, and the surface is coated with paraffin or any suitable tree paint. At grafting time, dormant scions from storage are prepared, as shown in Figures 29, 30, and 31, by making a long cut on one side and a short one on the other, so as to leave a sharp chisel edge at the lower end. The scion is then held temporarily in place on the upper side of the stock outside of the bark while a mark is made with a sharp knife on each side. It is then removed and tapering cuts made down these lines for 3 or 4 inches, gradually coming together toward the lower ends. The scion is again taken in the hand and given a quick shave over the cut surfaces with a small plane and down the edges in such a way as to give the lower end a slight V shape, in order that they may be perfectly fresh and smooth and the form such as to make a close

fit with the cuts on the stock. The scion is then pushed under the bark between the two cuts in the stock as the bark is forced out. (Shown at *a* in Figure 33.) The strip of lifted bark is then cut away as at *b* and the scion tacked in place with two cigar-box nails. A second or third scion should be put in place if the stocks are large. The operation is then completed by painting over the entire surface of the scion and the cut surface of the stock with hot paraffin or melted wax. A complete outfit for use in top-working pecan trees by this method is shown in Figure 37.

Coating the entire surface of the scion, including all buds, with grafting wax appears to have been practiced first by Riehl. The use of paraffin has been practiced by various propagators for years but was original with Morris, even though others appear to have used it previously. Riehl used the slip-bark graft, which differs only in detail from the distal slot graft put forth by Morris. He trimmed the scions much the same as does Morris, but made only a single slit in the bark of the stock and drove the scion underneath,

FIG. 27.—A pecan grove in southwestern Oklahoma in process of development by budding the sprouts from stumps cut in the clearing of a forest during the previous winter

lifting and splitting it as the scion went downward. Riehl used only dormant scions, whereas Morris uses either dormant wood or that which has been freshly cut. In Connecticut, Morris meets with varying degrees of success by using either the distal slot or proximal graft at any time from late March to August. The best results are usually obtained in April, May, and June.

The Biederman method.—The Biederman grafting method (fig. 38), so named after C. R. Biederman, of Hereford, Ariz., a pioneer of the Southwest in the art of top-working the native walnut (*Juglans major*) with horticultural varieties of Persian walnut (*J. regia*), is a system of bark grafting closely resembling that developed by Riehl. It is used with stocks up to 6 inches in diameter, cut horizontally as for cleft grafting. The rough outer bark of the stock is pared away with a light ax or drawshave for several inches at the upper end, down to the more flexible inner bark. The prepared scion is then held in place outside the position under the bark where it is to be placed, while pencil lines are drawn on each side. The scion is removed and slender nails, one-half to five-eighths of an inch in length, are driven into the bark half an inch or more on the outside

of each of the lines to prevent any more of the bark than is necessary from being lifted in the operation that immediately follows.

A short vertical slit in the bark is made midway between the two lines, and the bark is slightly lifted on each side. A dormant scion cut much the same as for the Morris method (figs. 30 and 31), but concaved slightly on the inner side and with the outer bark pared away on the opposite side, is then driven under the lifted bark of the stock. Several scions are inserted (fig. 34) about the rims of all except the smaller stocks, and tacked in place. All scions are further secured by winding with waxed cloth, after which all cut surfaces and the scion are coated with warm wax.

FIG. 28.—The side or proximal graft in a pecan nursery; used in the early spring just as the buds burst into leaf

Biederman reports that in his experience thus far there has been no difficulty in Arizona because of heart rot due to cuts in the stocks 6 or more inches in diameter. On the contrary, he finds it very desirable to make large cuts when only by so doing is it possible to graft at a convenient height above ground.

THE CLEFT GRAFT

The cleft graft is so familiar to most propagators that a detailed description of the manner in which it is made is doubtless unnecessary. It is an old method practiced since a very early period, and because of its usual reliability it is regarded as being satisfactory. For such as find it to give good results year after year, especially if the amount of grafting to be done is not large, it would probably be unwise to change to another form. For those who are yet to learn their first system as well as those not wholly successful in using the cleft graft, some form of bark grafting would likely give better results if well mastered.

In any form of cleft grafting, except that for twigs and small branches, the stock is cut off horizontally with a saw, and the surface, particularly about the edges, is smoothed somewhat with a plane or heavy knife. In the old form of cleft grafting the stock was split or cut down through the center; but by more recent methods it is cut on

one or both sides of the middle, thus giving a somewhat elastic wall on one side and affording a better fit for the scion. Usually two cuts were made and a scion placed in the end of each cut.

In nursery practice at Lancaster, Pa., J. F. Jones uses a modified form of cleft grafting which he finds highly successful. Instead of making the cleft in line with the grain of the stock he begins near the edge of one side and makes a deep cut somewhat diagonally across the grain toward or even beyond the center of the stock. The scion is trimmed to a long wedge, thinner on one side than on the other and so placed that the thicker edge is firmly in place in the cut of the stock, with the cambium layers in direct contact. A small piece of paper is placed over the opposite side of the cut and made secure by tying with raffia, after which the paper, scion, and all are coated with melted wax. The paper is used to prevent the melted wax from penetrating the cleft from the rear of the scion to the cambium layers. The successive steps in this operation are illustrated in Figure 39.

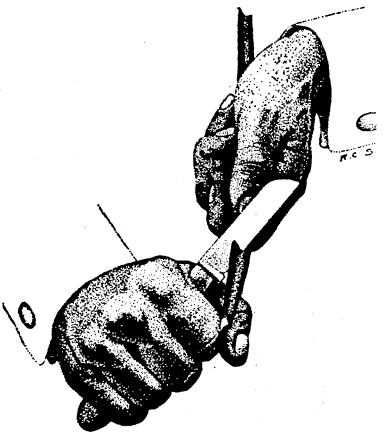

FIG. 29.—Making the long cut in the scion in bark grafting. When the surface is not to be smoothed with a plane, the knife should be held at an angle as nearly parallel with the scion as possible

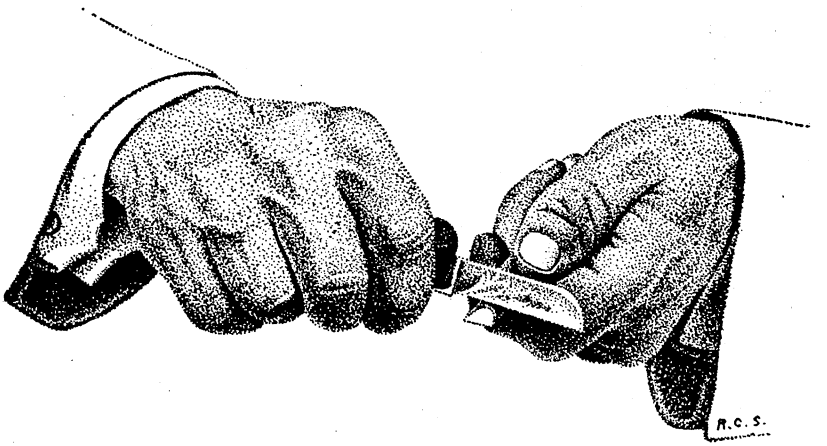

FIG. 30.—Making the short cut of the scion in bark grafting

Jones finds that although the slip-bark graft gives a higher percentage of living unions and allows of more rapid work than does this modified form of cleft graft, there is less subsequent loss with the latter because of the scions being blown out. Prac-

tically all of his spring propagation in the nursery is performed by this method.

SUMMER BUDDING

The method most commonly used in top-working pecan trees in the South is that of dehorning the trees in late winter and budding the resulting new shoots during the summer and fall. It is an excellent method for almost any variety of tree, because the young shoots are very full of vigor. In the North, dehorning is often done one year and the great crop of resulting new shoots either budded during the first year or grafted during the following year. The cuts in the branches to be worked as stocks are made at the same season as for grafting and at the same angle as in bark grafting. Care must be taken, however, to begin the cut on the high side immediately above a bud on the outside of vertical branches and on the upper side of inclining or horizontal branches, which will be left to develop and form a new top. The importance of making this cut at a sloping angle is indicated in Figures 40 and 41. The particular cut shown in Figure 40 was made at a point where the stock was about 3 inches across. It was immediately covered with tree paint. Superficially the wounded part appeared sound, as the paint apparently remained intact. However, examination by cross section revealed considerable decay that was rapidly taking place down the heart of the stock in the manner shown in Figure 41.

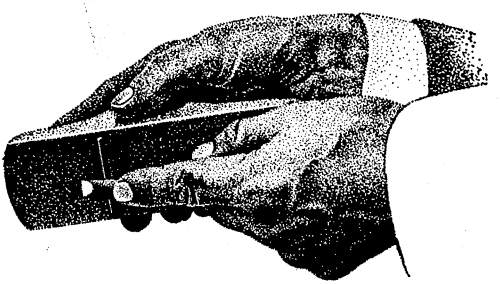

FIG. 31.—Smoothing the surface of the long cut of the scion in bark grafting, immediately before putting it in place

Growth from the stubs below the cuts is usually rapid, and an entirely new top is soon under way. As in other forms of top-working, a few small branches distributed throughout the original top should be left in dehorning. Once or twice during the early summer it may be necessary to thin out the new branches in order to divert the sap into those shoots desirably situated for budding. By July or August these new shoots should be in excellent condition for budding in accordance with the steps shown on the title-page and described under "Patch budding" (p. 12).

CARE OF GRAFTS OR BUDS

The subsequent care of any grafted or budded tree is no less important than the proper selection of stocks and scions used and skill in the operation itself. Scions not infrequently take only to die soon afterward, either because of neglect or by being blown out by the wind. Occasionally, as in the summer of 1925, unseasonable hot waves may be fatal to a large number of freshly started scions. Splice grafts, set under the ground and tied with raffia, need no attention until growth appears above the surface. Each tree should

then be trimmed as is necessary to induce development into single straight stems. In the nursery rows these trees should be tied securely to straight stakes and frequently retied to overcome any crooks. A band of raffia, or coarse string, put about a trunk so as to draw it to a straight stake will quickly correct a decided curve.

Staking and tying in this manner is applicable to trees budded in early spring during the latter part of their first year in the nursery as well as to the whole of the second year. As spring-grafted trees usually remain in the nursery but one year, the tying period is somewhat shorter than with budded trees. Trees budded late in summer can be made to furnish their own stakes during the remaining part of the year by leaving a stub a foot or more long above the point at which the bud was inserted, from which no sprouts are permitted to grow, and to which the slender growth from the new shoot may be tied for support. From trees budded early in the season, these stubs should be removed after the first four or five weeks and stakes used.

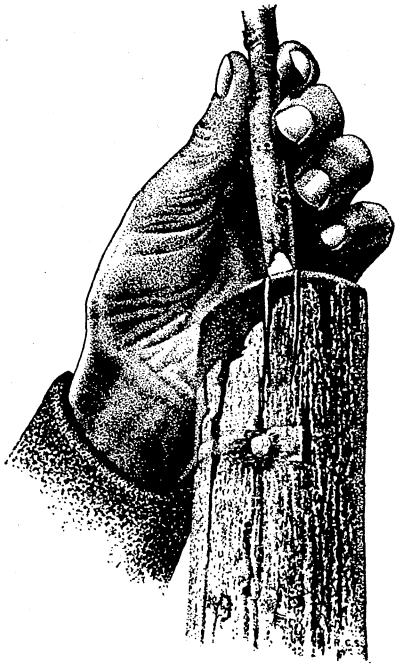

FIG. 32.—The scion being pushed under the bark of the stock

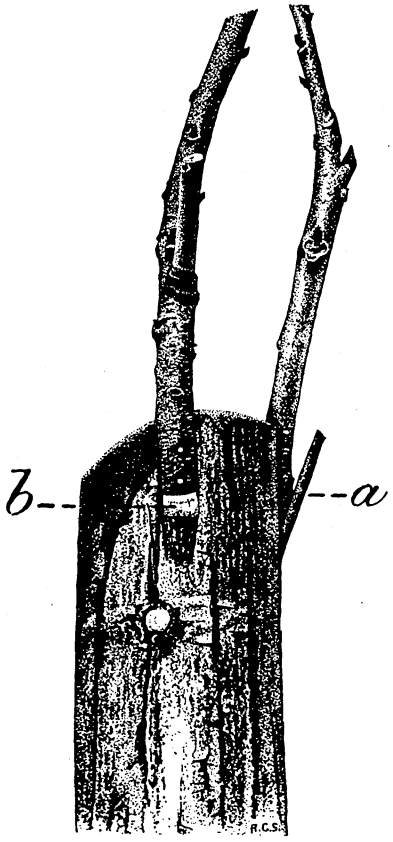

FIG. 33.—Two scions in place during the operation of grafting by the slot-bark method: *a*, The strip of bark that has been lifted by the scion in being pushed into place; *b*, the point at which this bark should be removed

With the budded tree or the small tree grafted above ground in the nursery, all waxed or paraffined parts must be watched closely, and not only should the binding material be unwound and reapplied

to allow for expansion due to growth but all breaks in the coating material should be repaired promptly. When growth is not forthcoming in due time from inserted buds which still appear to be alive, the tops of such branches as have been left should be twisted slightly so as to increase the pressure of the flow of sap to the bud. Soon thereafter these branches should be removed entirely.

New growth in top-worked trees should be carefully controlled at all times, enough being allowed to develop on the stock to prevent an excess of sap from going into the growth of the scion. As the latter

FIG. 34.—Coating the scion and all cut surfaces of the stock with hot paraffin

FIG. 35.—The Lake plan of inserting the scion of a black walnut when grafted by the slot-bark method. The feature of this method is the length of the scion surface placed in direct contact with the stock

FIG. 36.—Pecan stock cut at the proper angle in winter and coated with melted wax preparatory to grafting in spring

becomes stronger more of the growth on the stock should be removed. By the first spring after the tops have been grafted, all ungrafted branches should be cut away. This is sometimes possible at that time with budded trees; but as a rule, except with grafted stock, it is better to carry the old growth over until the second year.

In top-working hickory trees, W. C. Deming, of Hartford, Conn., who is highly successful in that line of work, allows no new growth to develop from the branches which are cut for the purpose. He finds that it often requires more than one year for the removal of

the seedling branches, depending, of course, upon the number of grafts inserted.

To a considerable extent it has been customary in the South to cut out the central branches of the tops of pecan trees which are to be budded, leaving the lower limbs for subsequent removal. This has the disadvantage, however, of raising the head of the tree to the next higher branches, which with low-headed trees may not be undesirable; with heads already high it is to be avoided.

With trees worked in the tops by either grafting or budding, the new growth must be watched carefully, as it may easily be blown out by the wind before the unions become firmly established. This is particularly true with budded and bark-grafted stock, as the attachment with unions of this kind is extremely frail during the first few months. The unions of bark grafts are but little stronger than are those of buds, although the nails and the binding material assist greatly. Such unions are the least likely to be blown out, and therein lies the chief advantage of propagation by that method.

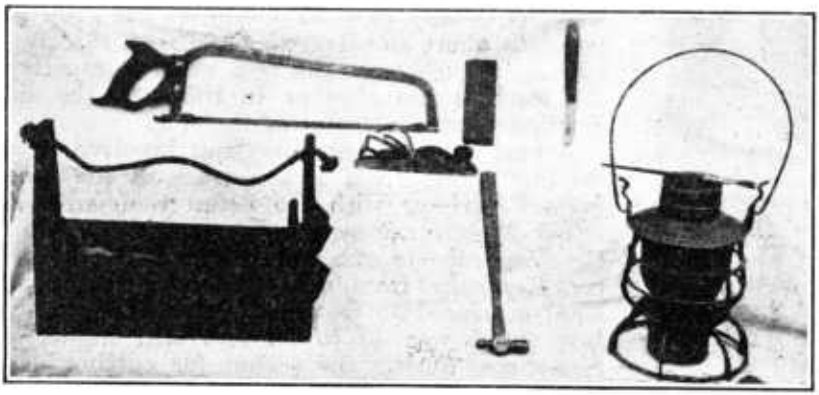

FIG. 37.—Outfit used by Wenzel in top-working pecan trees by the slot-bark method. The list of articles includes a saw with swivel blade, melting lantern, brush for applying the hot paraffin or wax, block plane, grafting knife, oilstone, light hammer, nails, and tool box

Excellent supports for tying purposes may be made by tacking long strips of wood, half an inch thick by 2 inches wide, to the stock below the union and extending the strips along the sides of the new branches. Stakes long enough to reach into the tree tops from the ground may be used wherever available and have the advantage of causing no injury to the trees.

SELECTION AND CARE OF SCIONS

The importance of cutting dormant scions for early grafting and for the first budding has already been touched upon. In the North it has been found safer to cut scions of such easily injured species as the Persian walnut in December while there is minimum likelihood of damage through winter injury. Shoots of that species are frequently so harmed that they will not take when used as scions; yet if left upon the tree they develop without showing evidence of having been injured. With species other than the Persian walnut,

the best time for cutting scions is in March, although results in the North are sometimes satisfactory with those cut as late as April 15. In the milder portions of the country, as in California and in the South, scions are cut mainly in February.

Shoots cut for scion wood should be stout, straight, and preferably a foot or more long. They should have at least 2 or 3 inches of intervening space between the buds. These shoots may be as long as 3 or 4 feet without objection, unless weak and spindling. The most desirable buds are those which were first to form during the year. Those forming toward the end of the season are usually weak and of little use in budding. In grafting, if the supply of wood is limited, these terminals are often found satisfactory. The wood most commonly preferred is that of the previous season's growth, although older wood may be used. C. L. Edwards, of Dallas, Tex., reports most satisfactory results with 2-year-old wood. In old trees good wood is usually hard to obtain, as the growth is typically short and irregular and with thickly set buds. In such trees the best wood is usually in the topmost branches or in those on the sides farthest from the center of the tree.

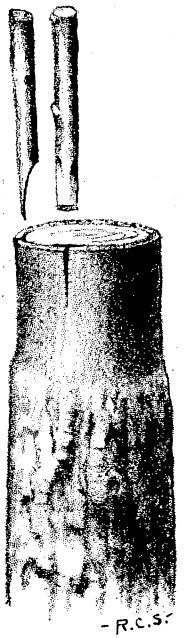

FIG. 38.—Bark grafting by the Biederman method, practiced in Arizona in top-working the native black walnut with improved varieties of the Persian walnut

Actual hazards are sometimes involved in obtaining scions from native trees in the forest, greater perhaps with the pecan than with any other American-grown nut tree. For example, the first branches of a certain pecan tree in northern Kentucky from which scions were once desired measured 59 feet from the ground, and the best wood was 40 to 50 feet still higher up. Sometimes during the season for cutting scions the forests for miles are flooded to a depth of several feet, and boats are necessary to reach the trees. Where the trees are extremely tall, the services of an expert climber are required. This raises the question—which can be determined only in each case—as to whether it would not be better to fell the tree while it is dormant, use what wood can be obtained from the top, and draw upon the resulting sprouts from the stump for the future supply.

A method of quickly increasing the available supply of scion wood is to cut back a branch, or where a larger supply is wanted to dehorn the tree in much the same manner as that practiced in top-working. If this is done in the spring before growth begins, a fine lot of good scion wood should be available by the time the summer budding season arrives. To make a permanent supply of propagating wood certain, it is a common practice among nurserymen to maintain a few mother trees which are used for no other purpose than to produce vigorous growing shoots. They may be trees left in the nursery rows from previous production, or those either lined out by themselves or interplanted in the orchard. Sometimes the mother trees are set at one-half the regular planting distance in the row one

way between the permanent trees. A good supply of grafting scions or bud wood from these alternate trees is made available each year by severe cutting back.

In procuring scions, cuts should be made 2 or 3 inches below the beginning of the last year's growth. This lessens the danger of loss by evaporation through the cut from near the buds which are to be used. It is well to dip the cut ends of the sticks in melted paraffin or wax to prevent loss through evaporation at those points. If cold storage is available, rooms having uniform temperatures ranging from 40° to 50° F. are most satisfactory, although some nurserymen use temperatures considerably below the freezing point. When refrigeration can not be had, a room in an ordinary basement will answer, if cool, dark, dry, and properly ventilated. Outdoor pits under ground and opening to the north are frequently used. Morris[4] reports satisfactory results from the use of a box on the basement floor in which the scions are alternated in layers with dead leaves. In common with the practice of many others, he sometimes embeds the scions in the sawdust of an ice house for storage until wanted and has found that they will keep in good condition for nearly a year in such sawdust. Edwards reports being able to hold scions for many weeks by merely sticking the cut ends in the earth on the shady side of a house.

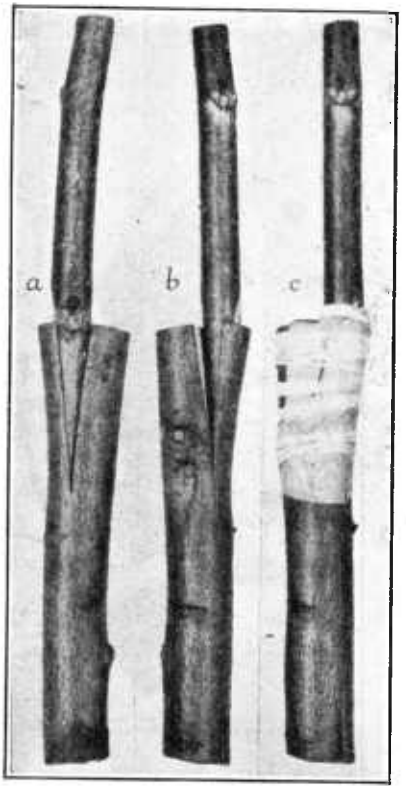

FIG. 39.—The Jones method of cleft grafting in the nursery: *a*, Cleft in the stock made from one side of the pith downward and toward the center or even across it. *b*, Back view of stock with scion in place. A small piece of paper will be pressed over the opening in the cleft before the stock is wound with raffia and coated with wax or paraffin. *c*, Scion in place secured with raffia and ready to be coated with hot wax

When the time comes for grafting, large operators employ a crew indoors to cut the scions into lengths a little in excess of the actual requirement. These are tied into bundles 6 inches in diameter and delivered to the workers in the fields as wanted. When only a few are to be used, it makes less difference as to when the scions are cut in short lengths. In the field, if a drying wind causes the scions to appear at all shriveled, it is well to keep the bundles wrapped in a damp (not wet) cloth or layer of sphagnum moss, or occasionally to immerse the bundle in water and to withdraw it quickly. Morris not only cuts but shapes the scions ready for insertion before taking them to the field. Sometimes he immerses the scion in a solution of

[4] Morris, R. T. Nut growing, p. 66. New York, 1921.

natural salts of sap known as Knudson solution, thus allowing shaped scions or buds to be cut at any time of day and used even a day later.[5]

Dormant scions cut in winter and intended for use in early summer budding should be held in cold storage until 24 to 48 hours of the time they are to be used. They should then be placed in a warm

FIG. 40.—Improper pruning for top-working. Stub too long and cut not made at proper place or angle to insure healing without decay. Cut should have been made at the crotch and with a long outward slope

room of considerable humidity, where it will be found that the bark will loosen quickly and soon slip freely.

The most desirable buds for use in either chip or patch budding are those on the sides of the branches that do not push into leaf unless compelled to do so when those farther out fail to function normally. These, of course, can be obtained only by sacrificing that part of the branch which extends beyond.

[5] Morris, R. T. Nut growing, p. 101. New York. 1921.

For use in late summer, buds are usually cut from the current season's growth, and only the most mature should be used. They should be prepared 10 days or two weeks beforehand by cutting away the leaves in whose axils they have formed. The cuts should be made an inch or more from the point of attachment, leaving stubs which will quickly dry up and either drop off entirely or at least not interfere with the welfare of the buds. Unless the leaves are so removed the evaporation through the freshly cut scion at the time of applying the bud will cause severe loss, in which case the method of covering the buds with melted paraffin or wax should be used.

There are possible advantages in selecting scions from heavily bearing trees, on the theory that the degree of productiveness of the parent tree is likely to be imparted to the new tree, but in the history of nut development thus far the degree of fruitfulness is so plainly dependent upon the cultural environment, including the influence of the stock used, that it is premature at this time to claim advantage in favor of scions so chosen.

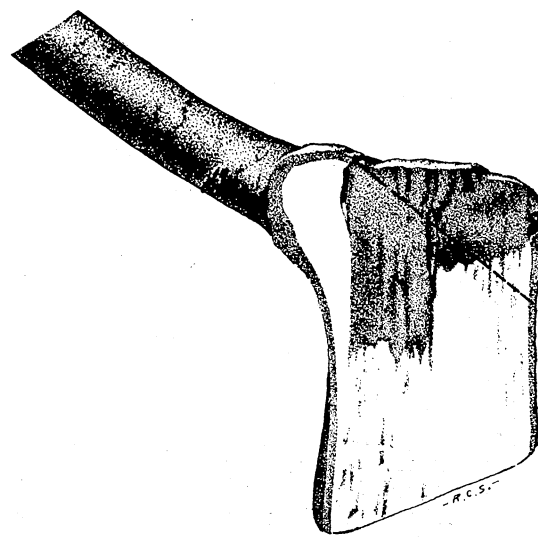

FIG. 41.—Pecan stock which had been cut at an improper angle. Although immediately coated with an impervious tree paint, heart-rot ensued, as shown. Whether for immediate grafting or for summer budding, cuts should be made at angles of about 45° (dotted line); otherwise a certain proportion of heart-rot will be inevitable, regardless of any paint that may be used

The greater certainty of trueness of variety, however, is one indisputable advantage in favor of trees propagated with scions from a bearing tree. Despite all precautions that may be taken in the nursery, mistakes are bound to occur, and few large orchards have yet been brought into bearing that did not develop—when the nuts began to appear—occasional errors in the variety planted. Great care in the matter of having varieties true to name is of prime importance, because of the disappointment after years of waiting to find that a wrong variety was planted.

SEED AND STOCK SELECTION

Irrespective of species, seed for planting and stocks for use should be carefully chosen and handled prior to planting. Nuts should be from healthy vigorous trees not unduly susceptible to disease or destructive insect pests. It is particularly important that the shells be well filled with rich plump kernels.

As soon as mature, the nuts should be harvested and dried sufficiently to dispel excess surface moisture. The hulls may be removed or not, as desired. With such species as the black walnut, the butternut, the Japanese walnut, and some of the filberts, the husks are likely to adhere closely to the nuts. With most hickories (including the pecan), the Persian walnut, the almond, the chestnut, the beech, and many of the filberts (including the hazel), the husks automatically dehisce or become separated from the nuts. Those of the latter group which do not thus behave are unlikely to be viable and should be discarded.

Fall planting of nuts is usually more satisfactory than spring planting, where there is no danger from rodents. Persian-walnut seeds, however, easily decay in soils that are either cold or wet, hence they usually give the best results when properly stored through the winter and planted in spring. The nuts of other species may be planted at any time after harvesting, or they may either be held in cold storage until spring or stratified in moist sand. In no case should seed nuts be allowed to become dry enough to impair their vitality. Seeds for use in stock work should be of the same species or closely related to those to be propagated upon the stocks.

PERSIAN-WALNUT STOCKS

The stock most satisfactory for the Persian walnut on the western coast is that of the northern California black walnut (*Juglans hindsi*). Hybrids of two local forms known as Royal and Paradox are sometimes used, but both are variable and difficult to obtain, and therefore are not used commercially. The former is the result of a cross of either the northern or southern California black walnuts with the eastern black walnut (*J. nigra*) and the latter of a cross between any black and the Persian walnut (*J. regia*). In the East the last named is the only stock used for this species. Because the Persian walnut is not as yet commercially hardy in the East, its propagation in that section is very limited, and planting is usually restricted to small numbers of trees in the more favored sections.

Jones has found that the Japanese walnut (*J. sieboldiana*) is unsatisfactory as a stock for Persian walnut, because the resulting trees invariably lack in strength and weight, are light, and inclined to be brittle.

PECAN STOCKS

The pecan is propagated almost entirely upon stocks of its own species. Experienced nurserymen are convinced that marked differences occur in the influence of stocks of certain varieties upon the subsequent growth of the grafted trees. For instance, in the Southeast, seedlings of Moore and Waukeenah, two local varieties from Waukeenah, Fla., are said by nurserymen to grow rapidly and to impart that characteristic to the new tops when used as stocks. Teche and Moneymaker are used to some extent with much the same results. In southern Louisiana, the water hickory, or bitter pecan as it is called (*Hicoria aquatica*), is used to a considerable extent, and by some it is preferred to the pecan. There is no evidence to show why this stock should not thrive under Louisiana conditions; in fact, in alluvial soils it may be a superior kind to use, but further

experience will be necessary before a definite determination can be made. B. M. Young, of Morgan City, La., conceived the idea of using this species as a stock for the pecan in lands too wet for pecan stocks. All trees in wet places worked to pecan, however, died after starting well into growth. Of other trees similarly worked and transplanted to higher land, all grew readily and became fine trees. In Texas various pecan stocks including Mexican seedlings have been tried, but at present little is definitely known relative to the permanent advantages of one kind of stock over another. Just now the Mexican stock is not in particular favor, partly because of the great difficulty experienced in getting seed that is uniform in character and viability.

Several species of closely related hickories in addition to the water hickory have been used. Of these, the mockernut (*Hicoria alba*) has been most often the one top-worked. The results have been distinctly variable. On the whole they have more often been unfavorable than otherwise, and the species is therefore not in favor with most of those who have had longest experience with it.

HICKORY STOCKS

Propagation of hickory varieties in general is of comparatively recent origin. The shagbark and the shellbark hickories (*Hicoria ovata* and *H. laciniosa*) are the best of this group so far as value of the nuts is concerned, but they are slow growers and not easy to propagate. Therefore, more rapid-growing species have been sought, with the result that the northern pecan and the bitternut (*H. cordiformis*) are in present favor. As the northern limit of the indigenous range of the pecan is reached by the river-bottom sections of southern Indiana and central and western Illinois, it may be reasonable to question the hardiness of the species as a stock at materially higher latitudes. However, as it is an established fact that the pecan tree is hardy beyond the range of nut production, this doubt may not be well founded. Perhaps the bitternut hickory would be safer for more northern use, but further experiments will be necessary before this point can be determined.

On private experimental grounds in Nassau County on Long Island, W. G. Bixby has found[6] that during two seasons of tests the shagbark hickory has been satisfactory as a stock for most varieties, in so far as immediate success in grafting is concerned. Likewise, the pignut (*Hicoria glabra*) and the bitternut were found satisfactory to much the same extent.

BLACK-WALNUT STOCKS

The only species of black walnut in this country of which there are now recognized horticultural varieties is the eastern black walnut (*Juglans nigra*). No other species for stocks has been used in its propagation except by experimenters who have not as yet arrived at practical decisions, and it is quite satisfactory as a stock when properly handled, with no apparent need for a substitute. Carefully chosen seed planted and grown in rich loamy soils and

[6] Bixby, W. G. Stocks for hickories. North. Nut Growers Assoc. Rpt. Proc. 15th Ann. Meet., pp. 48–50. 1924.

well cared for will grow rapidly and quickly develop into vigorous seedlings. Budded or grafted trees of certain of the present varieties come into bearing at about the same age as apple trees, despite popular opinion to the contrary.

Black-walnut stocks are used for the butternut and the Japanese walnut to the limited extent that these species are now being propagated as horticultural varieties.

STOCKS FOR ALMONDS

The almond is propagated upon stocks of its own species or of some other of peach relationship. Commercially, bitter hardshell almonds have long been used to the greater extent, but at present the peach stock is rapidly increasing in favor. For sites somewhat too moist for almond roots the peach is used, although the former should not be planted in soils that are poorly drained.

The Chinese wild peach (*Amygdalus davidiana*), a recent introduction, has been found to be highly satisfactory as a stock for the almond in tests at Chico, Calif., conducted by the Office of Foreign Seed and Plant Introduction. It has imparted greater hardiness and vigor to the almond, where it has been used, and apparently a certain degree of resistance to the oak fungus, a California disease seriously attacking the roots of ordinary almond and peach. This stock is still scarce and therefore not available to many propagators, but it is one of considerable promise.

STOCKS FOR OTHER SPECIES

Propagation of the chestnut in this country at the present time is largely confined to the uses of hybrid varieties resulting from crosses of the American chestnut or the chinquapin with either the European or Japanese species. In general, stocks of one species are unsatisfactory for varieties of another, although the chinquapin as a dwarf stock has been found by Morris to take almost all other chestnuts kindly. The seedlings of these hybrid varieties are usually the most desirable and so far as known are the only stocks being used to any extent commercially.

In the Pacific Northwest the Constantinople hazel (*Corylurs colurna*) is being used as a filbert stock to develop trees that will not throw out suckers from the base. Efforts have been made by various planters to obtain seed of the Chinese tree hazel (*C. chinensis*) for the same purpose, but without success as yet so far as known to the writer. The propagation of the filbert is therefore largely confined to methods of layerage.

The root systems of seedling filberts are distinctly unlike those of layered plants, as strong taproots (fig. 42) are developed rather than the fibrous root systems usual with the latter. Propagation by budding and grafting has the advantage of making a given quantity of growth suitable for such purposes go materially farther than when used in layering; and what is more important in a bearing orchard, it does away with the heavy strain upon the fruiting tree when propagation is done by layering of shoots about its base.

The pistache of commerce (*Pistacia vera*), grown in this country to only a limited extent, is grafted upon stocks of the Chinese

pistache (*P. chinensis*). The coconut (*Cocos nucifera*), grown but little in this country and then only in the warmer parts of Florida, is reproduced by seeds only.

EQUIPMENT USED IN PROPAGATION

The necessary outfit for propagating, either by budding or grafting, includes the scions or bud sticks, some kind of an instrument having one or more sharp edges for making the cuts, a hone or oilstone for keeping the instrument sharp (unless it is of special design that can not be sharpened), binding material for holding the scions in place, and usually some kind of wax material for sealing all cut surfaces from which serious evaporation might take place. The tools most commonly used in budding are illustrated in Figures 11 and 12. That shown in Figure 11 consists of two straight-handled knives having rigid blades especially tempered and mounted together upon a block in such a way as to be perfectly parallel. With a little practice in the use of single knives of this kind it is possible to perform the operation of patch budding. A rectangular cut is made about the bud with its opposite sides approximately parallel. The bud is lifted, laid on the stock where it is to be inserted, and used as a pattern while cuts are made on all its sides in the bark of the stock. Removing the bud, the cuts in the bark are made as much deeper as is necessary, the bark lifted, and the bud is quickly put in the matrix and securely fastened, as in any other form of patch or chip budding. On the handle end of the knife with the single blade, or on that of one of the two knives mounted together there should be a short rounded steel or brass point for use in prying the bud loose from the bud stick.

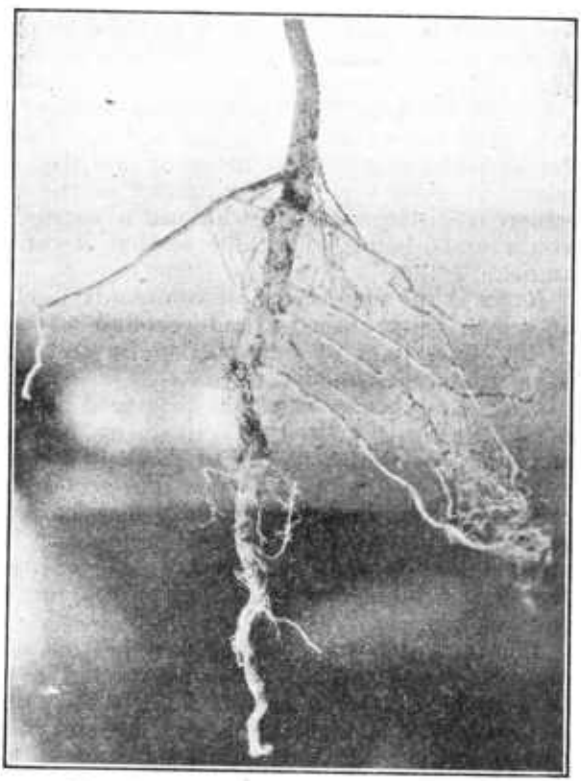

FIG. 42.—Typical taproot of filbert seedlings

The tool illustrated in Figure 12 consists of four thin blades so mounted upon a metal block that all cuts can be made by a single

movement. It is used in somewhat the manner of a punch, but instead of all blades being pressed into the bark at one time, that on the left is driven beside the bud and taken over to the right, making the cross cuts as the tool is moved around and pressed firmly against the stock. While the tool is still in place, a quick movement is made by which the bud is flipped out and into the other hand. Using the same tool, the matrix is made in the stock and the bud quickly put in place. Various modifications of these three types of budding tools have been devised, but so far as known none have advantages not possessed by these original types.

In grafting large stocks a saw will be a necessary part of the equipment. It should be sharp and the teeth coarse rather than fine, as saws with fine teeth are much inclined to pinch in the green wood. A gum from the sap is likely to form on the teeth and sides of the saw, which can be removed by frequent washing with water or, better, with kerosene, but the oil must be carefully wiped away with a dry cloth before using the saw again. To obviate the difficulty as far as possible it is well to use a saw that is narrow from edge to edge. A good type is that known as the California pruning saw, which is distinguished by having a narrow blade held in position at the ends, being adjustable so that it can be made to cut at any angle.

Raffia is the material most commonly used in tying buds in place, or scions when inserted underground. It is obtained from strips of the inner bark of a tropical palm and can be had at most seed-supply houses at moderate cost.

Waxed cloth may easily be prepared by immersing ¾-inch strips of old muslin in melted wax, draining, and allowing to cool. These strips can be folded back and forth in lengths of an inch or more, as desired, and cut at the ends into rectangular pieces. For use in chip or patch budding, the cloth may be left a foot or more wide, and strips may be torn from it as needed. To some extent nurserymen in the South exchange with their employees new bed sheets for those which have been used a year or longer, which therefore tear readily.

The wax used for grafting may be that of any standard formula or ordinary beeswax. A formula long in use for apple propagation in the North consists of 4 parts by weight of rosin, 2 parts of beeswax, and 1 of tallow. For use in cold weather this can be changed to 4 pounds of rosin, 1 pound of wax, and half a pint of raw linseed oil.

J. F. Jones, of Pennsylvania, uses wax consisting of 16 pounds of rosin, 4 pounds of beeswax, half a pint of linseed oil, and one-eighth of a pound of lampblack melted together, thoroughly stirred. This is prepared in about 40-pound quantities and held in stock. When about to be used, a desired quantity is remelted and placed in a square-cornered, tin container about 8 inches wide by 12 inches long, about as deep as wide, and having a handle like that of an ordinary bucket. Running lengthwise through the container near the bottom and open only at one end, there is a tunnel into which a tray containing a 1-pound red-hot brick of carbon is placed to keep the wax hot. The brick usually burns from four to six hours and for field use is entirely satisfactory for half a day at a time.

The wax is applied with a swab made of a heavy cloth tied about the end of a stick. The purpose of the lampblack is not to give color but to impart superior toughness to the wax. In all but the hottest weather, when the heat attracted by the black color may work disadvantageously, this wax is highly satisfactory.

R. W. Fair, of Texas, reports that linseed oil in any mixture has been found detrimental to nursery grafts in that State and should be avoided. A formula which has proved very satisfactory to him consists of 4 pounds of rosin, 2 pounds of beeswax, and half a pound of tallow. For use on cold days when the wax is inclined to be stiff, a small quantity of wood alcohol is added.

F. T. Ramsey, of Austin, Tex., concludes that wood alcohol is unsafe in any wax and that grain alcohol alone can be used with safety.

Wax to be used cold is made by melting and mixing the ingredients together until thoroughly blended, after which it is poured into a bucket of water while still hot. As soon as the wax is sufficiently cool, the hands are greased and the wax pulled until of the desired texture. For use when only a small amount of grafting is to be done, a good grade of ready-made wax can be obtained from seed-supply houses.

The use of melted paraffin, introduced by Morris, is still in the experimental stage, although highly encouraging results are commonly reported. Some experimenters report that scions coated with paraffin as soon as cut and held in cold storage give a lower percentage of successful grafts than those not coated, while others make no complaint but on the contrary highly commend the method. In the present stage of experimentation with melted paraffin, it is apparently better on the whole not to use it on scions to be stored, except experimentally, as highly satisfactory results are being obtained by the methods already described under the heading, "Selection and care of scions" (p. 35).

In Lake's experience, the application of melted paraffin at a temperature as low as possible to insure a thin coating is most satisfactory. When applied at too low a temperature paraffin used alone becomes flaky and soon cracks open. Likewise during extremely warm weather it is unsatisfactory, as it is fairly certain to melt and run out of place. To remedy this and to prevent cracking at any temperature, Morris now uses one-third part of pine gum, a commercial form of which is known as gum thus and may be obtained from dealers in chemicals.

Roy A. Reed, of Bowie, Ariz., reports that in the hot sun of the Southwest paraffin is penetrated by heat rays to such an extent that the swelling buds are burned. He is now experimenting with various substances with a view to overcoming this trouble. Temporary shading of each graft with a strip of paper until it has sprouted overcomes the difficulty from such effects and is so successful that it is now a common practice in the North as well as in the South. The paper has the further advantage of keeping birds from alighting upon grafts and breaking them off.

Paraffin in the form commonly used in propagation work is generally available at grocery stores. For melting and keeping the paraffin warm, various types of heaters have been devised, the best

known of which perhaps is a remodeled railroad lantern having a deep cup soldered inside the top directly over the flame. Lake has found that in the vicinity of Washington alcohol makes too hot a flame for spring use as fuel, and on windy days it is constantly being blown out. This may be caused by a defect in the particular lantern he has used. He finds that signal oil from railroad shops, although difficult to obtain, has been much more satisfactory, as it yields a lower heat and is less inclined to be blown out.

SUMMARY

Nut trees do not reproduce themselves true to variety when grown from seed, but must be propagated asexually like other fruits. Propagation with most species of nut trees is more difficult than with ordinary fruit trees, although the general principles are the same. Certain methods of budding and grafting are practically identical with nuts and with fruits, but with probably the single exception of the almond, which is propagated about as easily as the peach, a much higher degree of skill is required with nuts. Methods of propagation which are successful with the more difficult species of nut trees are invariably so with most of the ordinary fruit trees.

Layering in some form is at present practiced only with the hazels. Leading experimenters are investigating the field of budding and grafting with hazel species, and it is not improbable that future propagation will include those methods, particularly with varieties practically impossible to propagate by layering.

Propagation of varieties of nut trees belonging to the walnut family is difficult, but there seems to be no reason why with proper precautions and ordinary skill it should not be successfully accomplished.

The ability to propagate nut trees should be acquired by every grower, so that if the occasion arises he may top-work to better kinds any trees of spurious or inferior varieties in his planted orchards, may work over seedlings in his native groves, or if necessary may establish a branch or two of a variety for pollination purposes in the tops of trees of standard varieties. With new varieties, it often happens that scions only are available and not trees. Trees in sufficient numbers for orchard planting may not be available. In any case, by obtaining from a nursery a single tree true to variety, the planter may provide himself with an early supply of scion wood with which to increase his planting stock.

Regardless of other reasons that prompt a mastery of the art of propagation, the nut orchardist will find his ability to bud or graft his trees successfully of great advantage in handling his orchard.

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